California Energy Commission

Innovative Program Element Peak Load Reduction Program

SB5X 2003 Supplemental Report

Appendix A: Summaries of Sampled Projects

TABLE OF CONTENTS

Project Number:	SB5X3001
Project Name:	Novatia

Project Overview

Project Summary

Novatia contracted with the Energy Commission to develop and run a rebate program that would provide rebates of $1/square foot of installed solar window screens to California ratepayers. The total demand savings were estimated to be 9.0 MW with $3,455,738 in incentives.

Key Participants

Allan Goff, Novatia's president, submitted the original application, which included the demand savings calculations and project work plans. For this project, Novatia chose to exclusively use solar screen products from Phifer Wire Products, Inc.

Technology Overview

Solar radiation entering through windows can contribute significantly to residential heat gain. Using solar screening devices over existing window openings can mitigate these solar heat gain effects. This results in increased comfort levels and decreased residential air-conditioning (AC) demand load and usage, especially during summer peak periods.

Evaluation

Monitoring and Evaluation Procedures

Nexant engineers worked closely with the Energy Commission staff to develop a reasonable evaluation method for the potential demand reduction impacts of this project. The evaluation method focused on determining the average demand savings per installed unit of product (i.e. square foot of solar screen). Nexant conducted pre- and post-installation site surveys of participating homes. Calculated demand savings included evaluation of the following variables: solar insolation levels for various locations, average residential AC-unit efficiency, existing internal and external shading devices, and occupancy levels.

Novatia reported, via the Energy Commission, the total square footage of installed product; Nexant accepted this figure.

Program Savings

Program savings are calculated as in equation (1) below: the product of the average demand reduction per square foot and the total reported quantity of installed product:

$$(1) \qquad (2.44W / ft^2) \times (1{,}700{,}000\, ft^2) = 4.148MW$$

Error Analysis

Pursuant to the project's MV&E efforts, the following section and table describe the magnitude and nature of error in the demand savings analysis.

- Modeling error: Nexant assumed 15 percent error in the demand savings calculation methodology.
- Assumptions of stipulated factors: Assumptions made in the analysis include average usage patterns and efficiencies of typical residential AC-units. Nexant assumed 15 percent error in stipulated factors.
- Sampling error: reporting of 1.7 million square feet of installed solar screens is assumed to contain an error of 1 percent.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	15.0
Sampling Error	1.0
Assumptions of Stipulated Factors	15.0
Project Total Error	21.2

Program Effectiveness

Verified savings	=	4,148 kW
Reported savings	=	2,361 kW
Realization Rate	=	175.7 percent

Project Number:	**SB5X3002**
Project Name:	**SCS Engineers**

Project Overview

Project Summary

The contracted goal for this project was to install 2.49 MW of electric generation capacity statewide by installing microturbines. The Energy Commission contracted value for this project was $622,500.

The microturbines were to run off fuel from waste landfill gas. The microturbines use a portion of the landfill gas to produce electricity to meet the landfill facility's existing power requirements. This gas would otherwise be flared into the atmosphere.

SCS Engineers completed installations of three sites: 420.0 kW of nameplate capacity at the OII Landfill in Monterey Park, 300.0 kW of nameplate capacity at the Calabasas Landfill, and 210.0 kW of nameplate capacity at the ACME Landfill in Martinez, for a total of 930.0 kW of installed nameplate generation capacity at all three landfill sites.

Several factors contributed to SCS Engineers being unable to reach their initial generation capacity goal—a weak economy and regulatory hurtles contributed. These two factors caused SCS Engineers to have a difficult time recruiting program participants. In addition, SCS's original microturbines suppliers, Honeywell Power Systems, withdrew from the market, forcing SCS to find a new supplier.

Key Participants

Jeff Pierce, Vice President of SCS Engineers is the authorized representative on the grant application. Benny Benson, Project Manager for SCS Engineers, has been the primary contact for project and scheduling inspections information.

Technology Overview

The project uses modified natural gas microturbines to generate electricity using landfill gas as the combustion fuel. The modification consists of first sending the gas through a pre-treatment plant, which dries and pressurizes it, and then increasing the turbine throughput to account for lower methane content of landfill gas.

Evaluation

Monitoring and Evaluation Procedures

The project M&V plan consisted of pre- and post-installation inspections at the OII Landfill in Monterey Park and ACME Landfill in Martinez. However, a post-installation inspection at the ACME Landfill site was not possible due to project delays. Consequently, Nexant evaluated project savings based on control system and generation data obtained from the OII Landfill site during pre- and post-installation inspections.

Program Savings

Nexant based the approved savings for the project on the observed average power production of the units operating under typical summer peak period conditions at the OII

Landfill. At the OII Landfill, the claimed savings were 420 kW from the six 70 kW-rated turbine units. However, as the efficiency of the units degrades at higher outdoor air temperatures, power output during peak period summer conditions is frequently below rated capacity.

Table 1: Notes from Post-Installation Inspection at OII Landfill

Nameplate data	**Ingersol Rand, Powerworks, M/N: 70LW**		
Unit Number	**S/N**	**Run Hours**	**Inst. Output**
1	PW00124D1201	Offline,	Data unavailable
2	PW00126D1201	1181	63 kW
3	PW00122D1201	1173	Temperature offline
4	PW00121D1201	972	62 kW
5	PW00123D1201	1116	Offline
6	PW00128D1201	1277	50 kW

During the post-installation inspection, the project manager stated that under normal operating conditions, five of the six units are operational. The five units are reportedly able to supply the necessary power to the treatment facility. However, the landfill was unable to obtain a contract to sell excess power back to the utility. During the post-installation inspection, the three fully operational turbines were producing an average of 58.33 kW each. Nexant assumed that during normal operating conditions, each of the five turbines would be operating at this average of 58.33 kW, for total generation capacity of 291.7 kW.

This average power output of 58.33 kW is only equal to 83.3 percent of the rated nameplate power output of 70.0 kW due to three factors: the relatively lower efficiency at higher ambient air temperatures, the parasitic power consumed by the turbine itself, and the power consumed by the gas pre-treatment equipment. Since the inspection coincided with summer peak demand conditions, Nexant determined that the observed power generation data was representative of normal operating conditions during summer peak periods.

Nexant determined the level of verified peak power generation capacity based on the percentage of nameplate generation capacity actually realized under normal peak period operating conditions. This level of verified peak demand savings is equal to 83.3 percent of the installed nameplate generation capacity, based on the realized peak power generation of 58.33 kW for the 70.0 kW nameplate capacity microturbines at the OII Landfill site. The two remaining sites have a cumulative installed nameplate capacity of 510.0 kW. Consequently, 425.0 kW of peak generation capacity is the verified peak demand savings for the Calabasas Landfill and the ACME Landfill in Martinez.

The total nameplate capacity claimed for the three installed sites was 930.0 kW. The total verified peak demand savings at the OII Landfill in Monterey Park are equal to 291.7 kW. The total verified peak demand savings at the Calabasas and ACME landfills are equal to 425.0 kW. The total verified peak demand savings at all three completed landfill sites are equal to 716.7 kW.

Using their own calculations, SCS Engineers determined that of the 930 kW of installed nameplate generation capacity, approximately 720 kW would be operating during peak period conditions; SCS Engineers reported this number to the Energy Commission.

SCS Engineers continues to install microturbine power generation units at other landfill sites throughout California. Feasibility studies for some of their projects were initially conducted when CEC funding was still available though the Innovative program element. However, only the three projects detailed herein were completed through the Innovative program element. Other landfill sites that were later completed have not been quantified, and should be considered ancillary benefits of the Innovative program element. Through March 31, 2003, a total of 1000.0 kW in peak demand savings had been reported to the Commission.

Error Analysis

Three sources of error in the demand savings were identified: (1) instrumentation error, (2) sampling error, and (3) assumption errors. The instrumentation error is assumed to be small and is estimated at two percent. At the time of the inspection, Nexant was able to obtain demand readings on three of the six units. The resulting sampling error was five percent. Nexant was able to obtain demand readings at one set of outdoor air conditions. Nexant assumed that the ambient conditions at the time of the inspection would conservatively estimate the average summer peak period operating conditions of the units; this assumption error is estimated at ten percent.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	2.0
Modeling Error	0.0
Sampling Error	5.0
Assumptions of Stipulated Factors	10.0
Project Total Error	11.4

Program Effectiveness

Verified savings = 716.7 kW

Reported savings = 1,000.0 kW

Realization Rate = 71.7 percent

Project Number:	**SB5X3003**
Project Name:	**ECS Energy**

Project Overview

Project Summary

ECS Energy contracted with the Energy Commission to develop and run a program to provide rebates to hotels and motels for installing guestroom energy management (GEM) systems. The GEM systems monitor guestroom occupancy, providing local control to room lighting and HVAC systems. The total demand savings were estimated to be 7.4 MW with an incentive of $1,850,000.

Key Participants

Marc Koehler of ECS Energy submitted an application with demand savings calculations and project work plans. Mr. Koehler also coordinated with Nexant staff to conduct site inspections of participating facilities.

Technology Overview

The GEM system consists of an occupancy sensor, which monitors guestroom activity, and a local controller, which curtails room lighting and HVAC when rooms are unoccupied. Manual overrides are available and allow guests individual control during times of occupancy.

Evaluation

Monitoring and Evaluation Procedures

ECS Energy provided detailed peak demand savings calculations as part of their original application. Nexant evaluated and performed due diligence review on the savings calculations that were submitted. The calculations claimed an average potential demand savings per guestroom. Variables in the analysis included: a stipulated potential savings factor, a calculation of average peak electrical demand per room, and the disaggregation of electrical demand for lights and HVAC systems. As part of its M&V efforts, Nexant conducted both pre- and post-installation site inspections of participating facilities.

Program Savings

Program savings were calculated as the product of: (1) number of guestrooms retrofitted with a GEM system, (2) average peak electrical demand per room, and (3) potential demand savings:

$$\boxed{(12{,}683 rooms) \times (0.923 kW / room) \times (35\%) = 4.097 MW}$$

ECS Energy tracked the number of rooms included in the program. Nexant applied an assumed sampling error of two percent to the total number of reported rooms. ECS Energy calculated the value of 0.923 kW/room based on average lodging industry summer peak power demand and total number of rooms. ECS Energy assumed room lighting and HVAC systems account for approximately 50 percent of the total facility load. Equation (1) below:

(1) Average Summer Peak Load = 1.84 kW/Room.

A stipulated 35 percent potential savings factor represents the extent to which conditions exist where the GEM systems can curtail load (e.g. in the case where a room tenant does not turn off lighting and air-conditioning systems when leaving a room, the GEM system will have the potential to curtail load).

Nexant reviewed the calculations submitted by ECS Energy and found them to be accurate and reasonable, given the lodging industry data available. However, due to lack of more comprehensive data regarding potential for demand savings using the GEM systems, assumptions were made that introduced large uncertainty factors.

Error Analysis

Pursuant to the project's M&V efforts, the following table describes the error in the demand savings analysis. For the 12,683 installed units, reporting error of two percent was assumed. For the 35% savings potential per room, an assumption error of 30 percent was applied for use of this stipulated factor. Nexant assumed a 30 percent modeling error for use of the kW/room demand savings model. The large error inherent in the verified savings is due to assumptions made by ECS Energy regarding GEM system savings potential and room loads relative to lodging facility loads.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	30.0
Sampling Error	2.0
Assumptions of Stipulated Factors	30.0
Project Total Error	42.5

Program Effectiveness

Verified savings	=	4,097 kW
Reported savings	=	4,098 kW
Realization Rate	=	100.0 percent

Project Number:	**SB5X3044**
Project Name:	**ConSol – HVAC ComfortWise Homes**

Project Overview

Project Summary

This project was intended to promote and administer ConSol's ComfortWise homes program. The ComfortWise homes program requires builders of new California homes to: (1) seal ducts, (2) have the duct system professionally designed using Air Conditioning Contractors of America (ACCA) Manuals J, D, and S, and (3) install spectrally selective glass to meet or exceed ENERGY STAR® Home requirements. As a result of these energy efficient measures, home cooling loads are reduced, allowing installation of smaller AC units that require less power.

ConSol was awarded a contract of $3,160,000 for a goal of 10.5 MW of demand savings that would result from the enrollment and certification of approximately 10,500 new construction homes in the ComfortWise homes program.

Key Participants

Rob Hammon, a principal at ConSol, was the primary contact for this project. Site inspections were coordinated with Rex Hammon; inspections were conducted with Skip McGee, Dennis Rooker, and Shawn Seims. Nexant gathered additional information about energy simulation models from Rob Tamayo of ConSol.

Technology Overview

ConSol inspectors, who are California Home Energy Efficiency Rating System (CHEERS) certified raters, verified that all ComfortWise homes had ACCA approved ducts systems, that the ducts were sealed properly, that spectrally selective low E glass was used in the windows, that homes were properly insulated and sealed, and that the mechanical equipment met minimum California Title 24 standards. The ComfortWise homes program ensured proper sizing of residential air-conditioning units, which typically resulted in a one-ton downsizing from a non-ComfortWise home. All measurements were verified twice, during initial and final inspections. ConSol required that one out of every seven homes built were inspected and at least one of each construction plan type was included in the sampling protocol.

ComfortWise homes are reported to be 30 percent more energy efficient than Model Energy Code (MEC), and at least 15 percent more energy efficient than Title 24 compliant homes.

Evaluation

Monitoring and Evaluation Procedures

The MV&E procedures consisted of three steps: (1) observe initial and final site inspections by ConSol raters, (2) verify assumptions and calculations (1 kW/home reduction in load), and (3) establish an average coincident peak use of residential AC units. Nexant then used this estimate to determine the project's average peak load reduction.

Nexant staff accompanied ConSol's raters during final site inspections on May 23, 2002 and September 9, 2002. During these site inspections, raters adhered to the guidelines and protocols set forth by the ComfortWise homes program. The homes' insulation, AC unit, duct sealing, duct layout, and windows were also inspected during the initial inspections.

Raters performed blower door and duct leakage tests. Additionally, manufacturer specifications of AC units were verified during final inspections. During inspections, the raters fill out inspection forms detailing all ComfortWise requirements. In order to receive a ComfortWise home rating, a home must have satisfied ComfortWise program requirements.

ConSol calculated a peak load reduction per home of 1 kW, resulting from a one-ton downsizing of each residential AC unit. ConSol calculated these demand savings by comparing new homes built to code, according to 30-year engineering practice principles, with homes built according to the ComfortWise home standards. ConSol used software simulation models to size mechanical systems. Micropass was used to check for Title 24 compliance. This yielded a load for a given house. The AC was sized accordingly. Each room's load was checked against ACCA manuals, and all room loads were integrated in order to assure proper duct sizing.

Nexant verified assumptions in ConSol's simulation software for determining cooling loads for ComfortWise homes versus Title 24 compliant homes. Because the majority of the homes participating in the program were in climate zones 10, 12, and 13 (Climate Zone 12 – Sacramento, Climate Zone 10 – Inland LA, and Climate Zone 13 – Fresno and Bakersfield), these houses were selected for testing ConSol's cooling load calculations and assumptions.

The ComfortWise minimum requirements are spectrally-selective glazing, ACCA duct design with tested leakage of less than 2 percent, and inspections of other envelope installations, such as window sashes, caulking, and insulation. The one ton cooling load reduction for each ComfortWise home AC unit was calculated by averaging the rated power differences between 3, 4, and 5 ton units from three major manufacturers of HVAC equipment (Bryant 561C AC condenser (10 SEER), Carrier 38BRB AC condenser (10 SEER), and Lennox HS21 AC condenser (12 SEER)). ConSol's calculated demand savings from these manufacturer specifications were 1.2 kW/ton after dropping the outlier data; they conservatively claimed savings of 1 kW/ton. Nexant concluded that the one ton cooling load reduction per ComfortWise home, and the 1 kW/ton demand reduction for each ComfortWise home is conservative and appropriate for use in ComfortWise home demand savings calculations.

Power monitoring of AC units in ComfortWise homes proved infeasible, as limited resources prevented Nexant from installing monitoring equipment on a statistically valid sample of AC units in participating homes.

In order to determine a coincident diversity factor (CDF) for residential AC units in California climate zones during summer peak demand hours, Nexant compiled information from the Proctor Engineering Group (PEG) report, "Effects of Occupant Control, System Parameters, and Program Measures on Residential Air Conditioner Peak Loads," to determine the most appropriate CDF. Based on information provided in the

PEG report, and Nexant's assumption that AC units in cycling mode are on 50 percent of the time, the CDF for AC units within the peak period for all ComfortWise homes was calculated at 56.7 percent. See Table 1 below:

Table 1: Coincident Diversity Factor for Residential AC Units

Compressor Mode	Average Mode Frequency*	Compressor % On Time	Coincident Diversity Factor
Continuous Off	14.1	0%	0.0
Cycling	58.0	50%	29.0
Continuous Cycling	6.6	100%	6.6
Continuous On	21.1	100%	21.1
Total	99.9	-	56.7

* Calculated from PEG report of seven different residential CDF studies

Program Savings

Nexant applied the CDF of residential AC units during the summer peak demand period to the 4,991 ComfortWise homes that had been completed through March 31, 2003; this is shown in the equation below:

$$(4{,}991 houses) \times (1 kW / house) \times (56.7\%) = 2.830 MW$$

The program realization rate is low due to the fact that ConSol assumed demand savings of 1 kW/ home, and did not apply a coincident diversity factor to those homes that participated in the program. Nexant engineers determined that applying the CDF results in a more accurate calculation of realized peak period demand savings.

Error Analysis

Nexant conducted an error analysis of the evaluation methodology. The following identifies the equation used to calculate the demand savings for this project:

(1 kW/Home) x (Number of Homes) x (CDF) = Total kW Saved

The following errors were recognized for the above equation, and are listed with their respective error. Modeling error of 10 percent was attributed to use of Micropass. A sampling error of 2 percent was assumed for reporting (sampling) error. Error of 25 percent was assigned for use of the calculated coincident diversity factor.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	10.0
Sampling Error	2.0
Assumptions of Stipulated Factors	25.0
Project Total Error	27.0

Program Effectiveness

Verified savings	=	2,830 kW
Reported savings	=	4,891 kW
Realization Rate	=	57.9 percent

Project Number:	**SB5X3010**
Project Name:	**Quantum Consulting**

Project Overview

Project Summary

Quantum consulting and BacGen Technology proposed to launch a three-tiered program called The Municipal Wastewater Retro-commissioning Program (MWRP). The three tiered approach included (1) fully funded implementation at 10 facilities, (2) partially funded implementation at an additional 10 facilities, and (3) technical assistance at 100 facilities. In total, the program was expected to attain 6 MW of peak demand reduction, for a contracted incentive amount of $1,248,390.

The program focused on small and medium size wastewater treatment facilities (flows of 0-5 MGD). Specific measures depend on the type of wastewater treatment process at a given plant. However, most measures encountered during Nexant's M&V activities were aimed at reducing blower motor energy consumption by monitoring dissolved oxygen (DO) levels and controlling the blower motors (via variable frequency drives or inlet guide vanes) to maintain DO concentration set-points.

Key Participants

- Derrick Rebello- Principle, Quantum consulting contact
- Martin J. Shain – President, BacGen Technology
- Joe Jackson- Fallbrook Waste Water Treatment Plant, facility contact for Nexant M&V activities
- Michael Fan – UC Davis Waste Water Treatment Plant, facility contact for Nexant M&V activities
- Mitri Muna – Moorpark Waste Water Treatment Plant, facility contact for Nexant M&V activities

Technology Overview

The first step in the MWRP program was to monitor dissolved oxygen (DO) concentrations over time at selected fully and partially funded implementation sites. Installation of DO sensors and a Supervisory Control and Data Acquisition (SCADA) system at each facility was required for DO levels monitoring. BacGen installed sensors and the data acquisition system. The next step was for BacGen staff to analyze the DO concentration profiles and come up with a method for (a) optimizing DO concentrations, and (b) controlling aeration equipment so that optimum DO concentrations are automatically maintained. Past studies have shown that DO concentrations are generally excessive, and therefore turndown of blower motors can be achieved with automated blower motor control.

Evaluation

Nexant's M&V plan treated projects falling in the first two tiers as *Population A* and programs falling in the third tier as *Population B*. Tiers 1 and 2 represented fully and partially implemented projects, respectively.

Nexant used a different M&V approach for each population. The goal of the M&V activities was to quantify the peak demand reduction for the two populations and use the figures to calculate a realization rate for the MWRP. Table 1 shows the results of Nexant's evaluation for the entire MWRP program:

Table 1: MWRP Program M&V Results

Total Reported Peak Load Reduction (kW)	Total Verified Peak Load Reduction (kW)	Realization Rate	Percent Error
1,345	351.6	0.261	45

Population A (Tiers 1 & 2) M&V Activities

A project list was obtained from Quantum Consulting and is shown in Table 2 below:

Table 2: Verified Projects, Population A (Tier 1 & 2)

Tier Number	Implementation Description	Installed facilities Verified	Installation in Progress
1	Fully funded aggressive implementation	6	4
2	Partially funded aggressive implementation	0	0
	Total	6	4

The M&V plan for *Population A* required pre- and post-installation measurements; therefore, only sites where installation had not already been completed could be selected for M&V activities. Of the four in-progress projects, one was on hold; Nexant therefore selected the remaining three for M&V activities. The goal of the M&V activities was to (a) verify project installation, and (b) quantify peak demand reduction resulting from each project. The projects selected for M&V activities were: UC Davis WWTF, Moorpark WWTF, and Fallbrook WWTF.

An average peak demand savings for the three facilities, along with the number of verified installed projects, was used to determine the total peak demand savings of 351.6 kW for *Population A* as follows:

$$kW_{verefied,\,population\,A}(351.6\,kW) = kW_{average\,sampled\,projects}(58.6kW)\,\text{*Number of Verified Projects}\,(6)$$

$$Where:$$

$$kW_{average\,sampled\,projects}(58.6kW) = \frac{kW_{verified-UCDavis}(30.7kW) + kW_{verified-Moorpark}(43.0kW) + kW_{verified-Fallbrook}(102.0kW)}{3}$$

Nexant inspected the three selected project sites and conducted activities to define the baseline peak power demand. Activities included:

- Instantaneous power draw measurements of blower motors using a Summit PowerSight PS3000 meter
- One week monitoring of blower motor current using Hobo 4-channel loggers and 150 amp current transducers.
- Facility staff interviews to determine baseline operation of blowers and seasonal effects on blower power draw. Seasonal effects were discussed with staff to asses how the plant would operate during the summer; adjustments to the measurements were made as required.

Installation of controls at all facilities has been delayed, and current forecasts for project installation suggest completion dates of August 2003 for all three projects. Due to the delays in project installation, Nexant and Beverly Duffy of the Energy Commission agreed to the assumption that the project would lead to a 50 percent reduction in the peak baseline power demand to quantify savings for projects in *Population A*.

Table 3 shows results of M&V efforts to date for projects from *Population A*.

Table 3: M&V Results for Population A (Tier 1 & 2)

Site	Verified Baseline Peak kW	Assumed Post Peak kW*	Peak Period Reduction kW
UC Davis	61.3	30.65	30.65
Fallbrook	86	43	43
Moorpark	204	102	102
Average	**117.1**	**58.55**	**58.55**

*Due to the fact that the projects have not been installed, Nexant has assumed that post-installation peak kW draw will equal 50 percent of the baseline peak kW.

Population B (Tier 3) M&V Activities

Nexant requested a project list for projects falling under the title of technical assistance sites (Tier 3) from Quantum. Quantum sent Nexant two sample reports, but did not send a project list for the Tier 3 sites. Quantum supplied Nexant with information on only two technical assistance (Tier 3) sites.

Table 4: Verified Projects for Population B (Tier 3)

Tier Number	Implementation Description	Installed Facilities Verified	Installation in Progress
3	Technical assistance	2	0
	Totals	2	0

The M&V plan for *Population B* required that reports be reviewed using the information therein to estimate the peak demand reduction resulting from each project. The two technical assistance sites reported were: Arvin WWTF and Sonoma Valley WWTF.

Arvin WWTF

Nexant reviewed the technical assistance report submitted to Mike Popichak, Chief Operator at the plant. Recommendations in the report included (1) a DO Monitoring & Aeration Control Strategy, and (2) a Sludge Processing Simplification. Through March 31, 2003, none of the measures recommended in the technical assistance report had been installed. Furthermore, Mike Popichak did not believe that any of the measures would be installed in the foreseeable future. Therefore, no peak demand reduction was verified for the Arvin technical assistance project.

Sonoma Valley WWTF

Nexant reviewed the technical assistance report submitted to Jim Zambenini, Chief Operator at the plant. Recommendations in the report included (1) replace diffusers, (2) DO control, and (3) shut down one aeration basin during summer. Through March 31, 2003, none of the above measures had been installed. Jim Zambenini informed Nexant that Sonoma Valley WWTF did not have plans to implement these measures in the future. Therefore, no peak demand reduction was verified for the Sonoma Valley technical assistance project.

Error Analysis

Population A Error Analysis

There are two sources of error in the quantification of peak demand savings associated with *Population A*.

Error in measuring baseline power draw was equal to 1.5 percent per PowerSight literature. Error associated with Hobo current transducers did not require quantification because the current monitoring data was only used for schedule verification. Based on a worst-case saving scenario of zero percent savings, and a best-case saving scenario of 80 percent savings, Nexant assigned a 45 percent error for the assumption that total verified savings are equal to one half of the peak period baseline power load.

Table 5: Error Analysis, Population A

Source of Uncertainty	Percent Error
Instrumentation Error	1.5
Modeling Error	0.0
Sampling Error	0.0
Assumptions of Stipulated Factors	45.0
Project Total Error	45.0

Population B Error Analysis

Currently there is no source of error for *Population B* because no verified savings are attributed to this population.

Program Effectiveness

Verified savings = 351.6 kW

Reported savings = 1,345 kW

Realization Rate = 26.1 percent

Project Number:	SB5X3012
Project Name:	BOMA of Los Angeles

Project Overview

Project Summary

The Building Owners & Management of Greater Los Angeles (BOMA of Greater Los Angeles) is a network of commercial real estate professionals that includes building owners, managers, developers, leasing professionals, medical office building managers, corporate facility managers, and asset managers. BOMA of Greater Los Angeles designed a number of demand saving measures for implementation at commercial offices, supermarkets, department stores, industrial facilities, and smaller municipalities.

The project consisted of six different measures used to achieve demand reductions during the summer peak demand period. Installation of every measure at a given site was not a requirement of the program. The six possible measures included:

- Applying window film
- Installing HID lighting controls
- Power Factor corrections
- Installing packaged HVAC and refrigeration energy management controllers
- Installing energy efficient lighting systems
- Upgrades to EMS, VSDs and HVAC systems

The total project demand reduction goals were 17 MW. With an incentive of $250/kW, the corresponding contracted incentive budget was $4.25 million. BOMA's incentive passed onto participants was $213/kW. BOMA issued the balance of the incentive, $37/kW, to CCA Management for project management and coordination services.

Key Participants

Sidney Pelston – BOMA Energy Program Coordinator

Enertech Systems – Lighting retrofit contractor

Accurate Energy – Lighting retrofit contractor

Bristol Park Industries – Manufacturer and engineering firm performing installation and commissioning of HID lighting control systems

Energy Saving Products – Engineering firm performing installation and commissioning of power correction systems

Encon International – Manufacturer and engineering firm performing installation and commissioning of package HVAC system energy recovery

V-Kool – Manufacturer and engineering firm performing installation of window film products

Halco Electric – Electrical contracting firm

Control Air – Firm handling comprehensive energy retrofits

Royal Window Film – Surveyor and installer of window film

Cal Air – Firm handling comprehensive energy retrofits

Technology Overview

Demand savings estimates and potentials detailed below are from documentation provided in BOMA's contract.

Application of window film

Conventional window films reduce solar gains by reflecting the sun's radiation. However, the visible light spectrum is also reflected, resulting in the need for additional internal lighting. The proposed window film technology is designed to block harmful ultraviolet rays and infrared radiation from the sun while allowing useful visible light to pass through. It is estimated that this technology reduces total solar heat gain by 50 percent.

Installation of HID lighting controls

This control allows lighting to reach full light level after a twenty minute warm-up period. After the warm-up period, lighting power demand is reduced by the controller, which limits the voltage input on the HID lighting systems. The estimated reduction is 20 percent of total power demand for the HID lighting.

Corrections of the electrical system power factor

Power factor corrections generate demand savings by reducing line losses. This measure was proposed for buildings with power factors below 90 percent. The power factor correction system is automatic, and continuously adjusts to provide the correct power factor for any demand condition. The estimate of savings is approximately 1 percent of the total building load.

Installation of packaged HVAC and refrigeration energy management controllers

Package unit controllers optimize the components of a HVAC system by overriding existing thermostats. The controllers prevent the HVAC system from exceeding a given temperature set-point once it is met, and prevent compressors from having unnecessarily long running cycles. A 20 percent reduction in operation of compressors has been estimated during high load periods.

Installation of energy efficient lighting systems

This measure proposed the replacement of existing T-12 magnetically ballasted lighting fixtures with T-8 electronically ballasted lighting fixtures. The expected reduction in demand was approximately 85 kW per 100,000 square feet of retrofit floor area.

Installation of energy management systems (EMS) and variable speed drives (VSDs) and upgrades of HVAC systems

Installing EMS systems can reduce the energy consumption of HVAC equipment through a variety of methods including start/stop technologies and temperature set-point optimization. Installation of VSDs on fan and pump motors reduces power demand by varying the speed of the motor to match the VSD output with the required load. While demand reductions result when equipment is constantly loaded, the greatest demand reductions for this measure occur during periods of partial loading. Since the total demand of HVAC systems varies based on the cooling load, the highest demand reductions are during summer peak demand periods. BOMA provided no estimate of savings for this measure.

Evaluation

Monitoring and Evaluation Procedures

Approximately 71 percent of the total demand savings were due to lighting measures. Thus, the primary evaluation of claimed demand reductions was focused on this measure. The M&V plan for determining the accuracy of the claimed kW reduction consisted of an evaluation of five sites. Four lighting retrofit sites were randomly selected for inspection. An additional site was randomly selected from the remaining measures. This site included a VSD installation measure, which accounts for 5 percent of the program's claimed savings.

Lighting M&V

The M&V for the installation of energy efficient lighting fixtures consists of an in-depth evaluation of the submitted lighting schedule and monitoring of a statistically valid set of fixtures to determine the operation within the peak period. Both of these activities were performed on each site to ensure a complete assessment of the claimed demand reduction.

For each of the four sites selected, a lighting equipment (LE) table was requested from BOMA. This spreadsheet provides a breakout of the existing and proposed equipment. In addition, distinct fixture wattages are applied to determine the connected kW reduction due to the lighting retrofit.

Site inspections were conducted to evaluate the submitted fixture counts and types in the LE tables. In the evaluation process, both pre- and post-installation inspections were conducted. However, all sites may not have had a complete verification of both systems. This is due in part to the timing of the completion of the BOMA projects in correspondence with the M&V activities. An analysis of the LE Tables indicates that the retrofits consisted of one-for-one change-outs. However, slight errors were found in fixture counts. The inspection results indicated that the LE Tables were within reasonable accuracy (±5 percent of the connected kW).

The fixture wattages included in the LE Tables were verified using a Standard Table of Fixture Wattages used in California's State-wide Performance Contracting Programs. The wattage table consists of a set of unique lamp and ballast combinations. Variations in factors such as efficacy and ballast factor ranges result in unique fixture codes. Each combination has an associated wattage that is determined based on an average of several different manufacturer specifications. For the purposes of this evaluation, the wattage table was only used as a guide to assess the reasonableness of the submitted wattages. It was assumed that the submitted wattages reference actual specification sheets from specific manufacturers.

While the LE Table provides a thorough breakout of the equipment, the necessary information to assign exact Standard Table fixture codes is not always represented. Therefore, in some cases, exact fixture codes could not be assigned. Whenever this occurred, the claimed wattages were verified to be in a range of wattages for similar fixture codes.

Monitoring of operating hours was conducted on a statistically valid set of fixtures. A precision-confidence level of 80/20 was used to determine the number of fixtures that would be monitored at each site. For an infinite population, this results in eleven (11) total points. Thus, twelve (12) points were monitored to account for the possibility of logger malfunction. All obtained data was used in the analysis for each site. The fixtures were randomly selected with a random number generator function. Since it is assumed that, in general, the usage groups with the largest demand savings will consist of the most fixtures, the total fixture counts were used as the population for the random selection. This feature encompassed all different usage types.

Monitoring took place in the months of January, February and March. While this period is obviously not in the peak period, the results provide an accurate account of the operation in the summer months, as it is assumed that all inspected sites maintain similar hours of operation throughout the year during peak demand hours. The logger data was analyzed to ensure that lighting operation was not reflective of change in daylight hours but solely on the time of day. The percent on time for each logger was calculated for the Monday through Friday, 2:00 pm to 6:00 pm time period, and was multiplied by the kW saved on each circuit. Summing up the monitored kW saved and dividing by the total connected kW saved results in the coincidence factor based on a weighted average of the circuits monitored. The average of this factor for the four sites is used for the program wide coincidence factor.

Installation of HID lighting controls

Claimed savings were approximately 2.4 percent of the total BOMA Program's savings. This measure was not included in Nexant's savings analysis. Inspections were not required for this measure.

Lighting efficiency interactive factor analysis

Lighting system retrofits reduce the connected load of the lighting system, and result in a decreased internal cooling load within the retrofitted space. To account for this effect, a default interactive savings factor of 10 percent has been applied to the verified demand reduction for the program's lighting measure. This factor is consistent with the evaluation of similar program elements.

HVAC M&V and analysis

Claimed savings were approximately 13.4 percent of the total BOMA Program's savings. This measure was not included in Nexant's savings analysis. Inspections were not required for this measure.

Power factor M&V and analysis

Claimed savings are approximately 3.6 percent of the total BOMA program's savings. This measure was not included in Nexant's savings analysis. However, for this measure, inspections were conducted at three sites on February 20, 2002, to verify project installation. Automatic power factor correction capacitors (PFCCs) help facilities to reduce amperage levels and overall power demand. At the time of these inspections, each PFCC unit maintained a PF of 0.98-0.99.

VSD installation M&V and analysis

M&V activities were conducted by a third party contractor, ASW Engineering, for all HVAC measures in the BOMA Program. Nexant utilized the results from ASW Engineering to assess the reasonableness of the claimed reduction in demand. The method used by ASW is based on manufacturer specifications, equipment performance curves and monitoring data. Nexant performed due diligence review on peak demand savings figures from ASW Engineering.

CO sensor installation M&V and analysis

Claimed savings are approximately 1.1 percent of the total BOMA program's savings. This measure was not included in Nexant's savings analysis. Inspections were not required for this measure.

Window film installation M&V and analysis

Claimed savings are approximately 6.4 percent of the total BOMA program's savings. This measure was not included in Nexant's savings analysis. However, a post-installation inspection was conducted at a Brookshire apartment high rise to verify the installation of the proposed window film. The window film had been installed at the time of inspection.

Thermal energy storage M&V and analysis

Claimed savings are approximately 0.4 percent of the total BOMA program's savings. This measure was not included in Nexant's savings analysis. Inspections were not required for this measure.

High efficiency motor M&V and analysis

Claimed savings are approximately 0.2 percent of the total BOMA program's savings. This measure was not included in Nexant's savings analysis. Inspections were not required for this measure.

Program Savings

Lighting efficiency savings

BOMA's claimed kW savings were based on the total connected load of the baseline and retrofit lighting systems. This assumes that all lighting in each building is on during the duration of the peak period. This is not a valid assumption. It is clear that some spaces will be unoccupied and the lights will not be operating. Thus, a coincidence factor has been applied to the total lighting load reduction. This factor is based on the monitoring activity previously described. The average coincidence factor is used as the program wide coincidence factor.

BOMA did not claim any savings for interactive effects resulting from a decrease in thermal load on the building. The default interactive factor has been applied to the verified demand reduction. The table below provides a summary of the site-specific demand savings determined by Nexant.

Table 1: Summary of Program Savings and Verified Demand Savings by Site

Site	Connected kW Saved	Coincidence Factor	Actual kW Saved	Interactive Factor	Interactive kW Saved	Total kW Saved
Pomona Library	101.8	0.94	96.1	0.10	9.6	105.7
Brookshire	38.4	0.97	37.2	0.10	3.7	40.9
1111 Broadway	105.0	0.92	96.4	0.10	9.6	106.0
Hookston Square	112.8	0.72	80.9	0.10	8.1	88.9
Program	**11,644**	**0.89**	**10,328.2**	**0.10**	**1,032.8**	**11,361.1**

VSD Savings

The management of Sony's Metreon facility retrofitted 13 air-handling units with variable speed drives. The air-handling units are located on the second and fourth floors of the facility. The previous fan-systems were constant-volume units with fan-motors varying from 7.5 to 25 horsepower.

Baseline data was taken on these fans before the variable-speed drives were installed. The total kW for all the fans was calculated to be 118.4 kW.

Management of Sony Metreon acquired data representative of the fan-system's operation after the VSDs had been installed. This data indicated that the fans were considerably oversized for the cooling loads of the structure, in that these fans are now running at the programmed minimum speed of 50 percent during the peak demand period. The energy and demand savings associated with this speed reduction are quite significant, as the power required to operate a fan at one-half speed is only one-eighth of that required at full speed. Post-installation data received from the Sony Metreon in San Francisco included data from September 20, which showed an outside air temperature of 85.9 degrees at one o'clock in the afternoon. The data indicated that every one of the fans was operating at the minimum 50 percent speed at that time.

ASW Engineering calculated the total kW demand reduction for VSD-equipped fans at the Sony Metreon. ASW Engineering concluded that conservatively placing the average speed of the fans during the on-peak period at two-thirds (66.7 percent) speed, an average demand savings of (1-.296) or 70 percent results. The average demand reduction for the facility then is equal to 70 percent of the baseline peak fan load, or 83.3 kW. The value of 0.296 is derived from the relationship between motor speed and motor load.

BOMA's claimed savings for this project are based on ASW Engineering's demand reduction calculations. Nexant reviewed, and approved, all VSD demand reduction and engineering calculations made by ASW Engineering. As a result, the reported peak period demand reduction for the VSDs measure is identical to Nexant's verified savings figure.

Program Savings

The following table provides a measure specific summary of the claimed and verified savings.

Table 2: Summary of Program Savings by Measure

Measure	Claimed Savings (kW)**	Verified Savings (kW)
Lighting Efficiency	11,644	11,361
HID Lighting*	409	409
Power Factor*	610	610
HVAC*	2,287	2,287
VSD	713	713
CO Sensors*	181	181
Window Film*	1,087	1,087
Thermal Energy Storage*	65	65
High Efficiency Motors*	26	26
Total	17,022	16,739

* Formal evaluation of the claimed savings was not done for this measure. In certain cases, inspections were conducted to verify program participation and installation of proposed equipment.

** "Claimed Savings" are based on activity reports prepared by BOMA and submitted to the ENERGY COMMISSION and Nexant.

Error Analysis

Assumption and sampling error for non-lighting measures is high due to the extensive number of measures that could not be directly inspected by Nexant for formal evaluation. Table 3 below details project error.

Table 3: Error Analysis

Source of Uncertainty	Lighting	Other
Instrumentation Error	5.0	2.0
Modeling Error	5.0	1.0
Sampling Error	15.0	44.7
Assumptions of Stipulated Factors	10.0	20.0
Total Measure Error	19.4	49.0

Program Effectiveness

Verified savings	=	16,739 kW
Reported savings	=	14,200 kW
Realization Rate	=	117.9 percent

Project Number:	**SB5X3014**
Project Name:	**Proctor Engineering Group**

Project Overview

Project Summary

This project consists of a systematic evaluation and upgrade of residential and small commercial AC units to improve efficiency through proper system maintenance. Specifically, savings are achieved by ensuring that AC units have proper refrigerant charge and correct airflow. The total demand savings were estimated at 26 MW, with an incentive of $5,180,000.

Key Participants

John Proctor, the president of Proctor Engineering Group (PEG), was the authorized representative listed on the grant application. Tom Downey, the Senior Project Manager, was the primary project contact that prepared the monthly status reports for the project. Mike Sims, the Field Manager, performed the training sessions for the participating contractors who serviced the HVAC units.

Technology Overview

This project focused on demand savings through proper maintenance of small packaged and unitary air-conditioning (AC) units. Savings were modeled from two types of repairs: (1) correction of refrigerant charge, and (2) correction of airflow restrictions.

PEG created a computer software program to analyze key performance parameters obtained during routine service visits. The software determined if the unit had the correct charge (refrigerant) levels and air flow settings.

Evaluation

Monitoring and Evaluation Procedures

Nexant's monitoring and evaluation consists of evaluating the data for the 21,123 AC units that were repaired as part of this program. Of the repaired units, 18,750 had refrigerant added or removed. Of the units with refrigerant adjustments, only 11,372 included both what appeared to be valid unit size and correct charge data. Therefore, 54 percent of the units that received charge adjustments had data complete enough for a quantitative demand savings analysis.

Program Savings

Nexant's savings analysis was based on PEG's assumption that all AC units had an average EER of 8. Nexant calculated the load for each analyzed unit at 8 EER using PEG's published formula for adjusting efficiency based on charge:

EER adjusted = EER 8 * EERnorm1,

Where EERnorm1 = EER at measured charge / EER at correct charge, and

Where Savings (Measured as a Percentage of Full Load) = 1 – EERnorm1.

The savings were summed for all the analyzed units, and results were extrapolated to the units that were shown as having refrigerant added or removed, but did not have enough information for full analysis. The result was an estimated savings from charge correction of 11,011 kW.

According to John Proctor, 55.5 percent of the stipulated savings for the project were due to charge correction. Based on this value and the total submitted savings for the project of 30,108 kW, the submitted savings for the charge correction totaled 16,710 kW.

Table 1: Refrigerant Charge Savings

Building Type	# Mischarged Units	Average kW Savings/Unit	Extrapolated kW Savings
Residential	6,920	0.58	4,029
Commercial	11,830	0.59	6,982

During its M&V review, Nexant noted that the formula used by PEG showed that AC units perform at peak efficiency when slightly overcharged. Therefore, if refrigerant was removed from serviced AC units to match nameplate data, efficiency would actually decrease. Nexant does not know whether PEG took this factor into account.

Nexant was not able to obtain enough quantitative test data to validate PEG's demand savings calculations for airflow correction on repaired units.

Due to the lack of quantitative test data for airflow correction, Nexant assumed that PEG's stipulated savings were correct for the remaining 44.5 percent of total submitted savings (30,108 kW). Demand savings for airflow correction are approved at 13,398 kW with high error due to the assumption that PEG's airflow correction demand savings calculations are correct. The total project error was calculated to be 55.0 percent.

PEG reported savings of 22,319 kW for commercial buildings and 7,789 kW for residential buildings. Total savings were reported as 30,108 kW.

Table 2: Submitted and Verified Savings and Realization Rates

Element	Savings (kW or %)
Verified Charge Savings	11,011
Submitted Charge Savings	16,710
Charge Realization Rate	65.9%
Submitted Flow Savings	13,398
Verified Flow Savings	13,398
Flow Realization Rate	100%
Total Verified Savings	24,409
Total Submitted Savings	30,108
Total Realization Rate	81.1%
Total Project Error	55.0%

Table 3: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	0.0
Sampling Error	0.0
Assumptions of Stipulated Factors	55.0
Project Total Error	55.0

Program Effectiveness

Verified savings	=	24,409 kW
Reported savings	=	30,108 kW
Realization Rate	=	81.1 percent

Project Number:	**SB5X3019**
Project Name:	**SCE Electrodrive**

Project Overview

Project Summary

This project is an incentive program to encourage the users of battery-powered non-road vehicles, specifically golf-carts and electric forklifts, to install energy management systems (EMS) on their battery chargers. These EMS systems are capable of curtailing battery charging during peak electrical demand periods.

The contracted demand savings for the project was 8 MW at $250/kW for a total contract value of $2,000,000.

Key Participants

William West is the authorized representative for this project on the grant application. Greg Kozykoski is the Honeywell DMC contact; Honeywell assisted SCE with program administration. Richard Cromie of Southern California Edison (SCE) is the Program Manager for the project and has primary contact responsibilities. His duties include marketing the program and acting as a liaison between the customer, contractor, and Honeywell.

Customers wanting to install EMS systems chose their own various contractors. In Nexant's sample sites, VaCom Technologies and Delta Pacific Energy were the contractors.

Technology Overview

The EMS battery charger systems allow for curtailment during peak demand periods. The system electronically logs when the chargers are disabled and notes if controls have been overridden. The EMS systems can be accessed via the Internet or modem to allow SCE to periodically check whether the controls have been functioning correctly or not.

Evaluation

Monitoring and Evaluation Procedures

The M&V plan consisted of dividing the sites into two population groups, (1) golf cart sites and (2) warehouse/storage sites. In each of the two groups, baseline monitoring was performed at three randomly selected sites to determine average peak battery charger demand. At each site, Nexant compared the monitored peak period demand to the reported peak demand curtailment savings so as to develop a site-specific realization rate. Nexant then used the average realization rate for the two groups to estimate the overall demand savings for the groups and, ultimately, the project's overall realization rate.

At the request of the Energy Commission, Nexant performed additional monitoring of the warehouse/storage sites. SCE identified eight sites that had discontinued peak curtailment for the off-peak season. Nexant monitored these sites to obtain additional baseline peak period power demand data. Nexant obtained valid data for seven of the eight monitored sites and calculated the realization rate for each site. These realization rates were combined with the three previously monitored sites to develop a more precise realization rate for the warehouse/storage group.

Program Savings

The demand savings claimed by SCE were based on savings calculations submitted by the EMS installation contractors. These savings were based on individual charger nameplate data rather than monitoring data. The total claimed savings amount was 3,149.1 kW for group 1, the golf cart group, and 5,952.8 kW for group 2, the warehouse/storage group.

In the warehouse/storage group, it appears as if most of the program participants included just enough chargers in the curtailment program to cover the cost of the EMS installation. However controls were installed on all the chargers at the site and, according to the SCE Project Manger, most of the sites curtailed all of the chargers. Therefore, Nexant assumed that the full monitored peak demands at the facility were curtailed.

Nexant determined that the average realization rate was 35.6 percent for group 1, and 27.3 percent for group 2. The corresponding verified savings were 1,120.7 kW for the golf cart group and 1,625.5 kW for the warehouse/storage group.

Error Analysis

Nexant identified three sources of error in the demand savings: (1) instrument error, (2) sampling error, and (3) assumption error.

The manufacturer guaranteed the instrumentation error to be within 3 percent of the full scale of the units. Due to the high savings claims relative to the actual energy usage of the battery charging circuits, most of the logging equipment was oversized. Most of the readings were in the range of 10 percent of the full design rating of the logging equipment. Nexant determined that this resulted in an instrumentation error of approximately 30 percent.

Nexant assumed that supply voltage and power factor of the units were constant for purposes of calculating the power from the monitored current. Nexant assumed the combined error of these two assumptions as being equal to 10 percent.

In total, 13 of 59 sites were monitored. The resulting sampling error is 2.9 percent. The resulting total error is 31.8 percent.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	30.0
Modeling Error	0.0
Sampling Error	2.9
Assumptions of Stipulated Factors	10.0
Project Total Error	31.8

Program Effectiveness

Verified savings	=	2,746 kW
Reported savings	=	9,260 kW
Realization Rate	=	29.7 percent

The observed realization rates for all of the monitored sites were low. Nexant believes that there are three main reasons for the low realization rates:

1. To determine the peak curtailment load, the control vendors multiplied the total charger load by a duty cycle, ranging from 21 percent to 85 percent, in the monitored sample. Based on our observations, Nexant believes that most of the estimated duty cycles were overestimated.

2. Nexant observed that at several of the sites, the savings calculations were in kVA nameplate data rather than kW. The true kW spot measurements indicate that the power factors for the chargers average 0.75. As a result, calculating power savings using kVA nameplate ratings will result in an over-estimation of savings by about one third.

3. Most of individual charger load data, including volts and amps, appears to have come from the battery charger nameplate. Nameplate data are “ideal ratings” and tend to be overestimated. It would be necessary to perform spot measurements of individual chargers to bring this nameplate data into line with the “real case” situations.

Project Number:	SB5X3029
Project Name:	Solatube

Project Overview

Project Summary

This project is to reduce California peak electrical demand by installing Solatube skylights (SolaMaster 21 inch model) in commercial office and warehouses spaces. In addition to the Solatubes, lighting controls are installed to ensure that existing lighting operates only when the additional light is needed. The total demand goal was estimated at 2.462 MW with an incentive of $596,512.

Key Participants

Solatube contracted directly with the Energy Commission to provide financial incentives to participating facilities.

Technology Overview

The addition of skylights to existing facilities helps to lessen the need for lighting. When properly located, skylights can provide sufficient natural illumination to significantly reduce the overhead lighting. Photo sensors can be added to monitor light levels and lockout the lighting when ambient conditions are adequate.

Evaluation

Monitoring and Evaluation Procedures

Solatube provided detailed peak demand savings calculations in their original application. Nexant based the verification effort on the evaluation and review of these calculations. Verified savings were based on Solatube's testing for the 21" Suspended/Hard Ceiling Solatube fixture. Solatube's testing indicated that each installed skylight provides, on average, the light output of two fixtures, each using (3) F032T8 compact fluorescent lamps.

Solatube estimated peak power savings at 0.224 kW per installed fixture installed. However, a peak power demand of 0.224 kW is not consistent with the fixture description determined by Solatube testing. From its own standard fixture wattage table, Nexant determined that two three-lamp fixtures operating with F032T8 lamps requires 87 watts per fixture, or 174 watts total. Based on Solatube's testing and Nexant's review, the value of 174 watts per installed skylight fixture is the verified peak power demand savings.

Additionally, Nexant conducted both pre-and post-installation site surveys of participating facilities. Through the writing of this report, Solatube reported that a total of 1,809 fixtures had been installed through the program.

For a total of 799 fixtures, installations were completed and rebates were issued. For a total of 1,010 fixtures, installations were completed, but rebate applications were incomplete, and rebate issuance was pending application completion and approval.

Program Savings

Program savings are calculated as:

$$(0.174kW / skylight) \times (1809 skylights) = 0.315MW$$

Error Analysis

Pursuant to the project's MV&E efforts, Table 1 describes the magnitude and nature of the error in the demand savings analysis. Due to the fact that lighting levels from the Solatube fixtures are not constant, 20 percent error has been assigned to the value of 174 watts per skylight. Reporting error was assumed to be 1 percent.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	0.0
Sampling Error	1.0
Assumptions of Stipulated Factors	20.0
Project Total Error	20.0

Program Effectiveness

Verified savings	=	315 kW
Reported savings	=	618 kW
Realization Rate	=	51.0 percent

Project Number:	**SB5XL001**
Project Name:	**Tenet Health Systems**

Project Overview

Project Summary

This project consists of a comprehensive lighting retrofit at 32 Tenet Health Care facilities throughout California. The total demand savings estimated were 2.2 MW with an incentive of $454,576.

Key Participants

David P. Garman, Director of Engineering Services for Construction & Design, served as the project-authorized representative.

Jo Carter of JC Consulting served as the primary contact.

Randy Decker and Chris Barrette of ES Performance managed the project installation.

Technology Overview

The retrofit measure consisted of retrofitting 4-lamp 4-foot T-12 magnetic ballast lighting fixtures with 4-lamp 4-foot T-8 electronic ballast fixtures. In addition, all exit signs with two 15-watt incandescent bulbs were retrofit with a single 2.5-watt LED array.

Evaluation

Monitoring and Evaluation Procedures

The M&V plan consisted of performing pre-and post-installation inspections. Pre-installation inspections were performed at five facilities to sample baseline equipment. The inspections consisted of verifying a random sample of line items from the submitted lighting tables and comparing the equipment list to the observed equipment.

Post-installation inspections were conducted at three sites: (1) JFK Hospital in Indio, (2) the Los Alamitos Medical Center, and (3) Desert Regional Medical Center in Palm Springs. The first two locations passed the inspection. However, in the case of Desert Regional Medical Center in Palm Springs there were several failed issues: lighting schedule descriptions were vague and lacked detail, and several fixtures listed on the lighting schedule were not retrofitted.

Program Savings

Nexant did not obtain detailed savings estimates for the Desert Regional Medical Center, upon request from the participant. As a result, Nexant was not able to verify whether or not demand savings calculations included coincidence factors, correct fixture power demands, or interactive HVAC savings calculations.

Verified demand savings were based strictly on the accuracy of the verified fixture counts recorded during the post-installation inspections performed by Nexant. Based on the post-installation inspection results, JFK Hospital and Los Alamitos Medical Center were assigned a 100 percent realization rate. Due to inaccurate lighting schedules, and based on Nexant's post-installation inspection, Desert Regional Medical Center was assigned a 60 percent realization rate.

The average realization rate for all inspected sites was equal to 72.5 percent; Nexant applied the verified, sample population realization rate to the entire project population. Total verified project savings were calculated at 1.316 MW.

Error Analysis

The Desert Regional Medical Center comprised approximately 68.8 percent of the estimated savings at the three inspected sites (267.9 kW of an estimated 389.2 kW). Consequently, error associated with the verified savings is high due to erroneous and inaccurate lighting schedules and data for the lighting retrofit at the Desert Regional Medical Center. The total calculated error for the three post-installation inspection sites was 38.8 percent. The value of 38.8 percent includes all error associated with an 80 percent assumed coincident factor and a 10 percent assumed AC cooling interactive factor. There is a five percent error attributed to standard fixture wattage values. Sampling error for the project was calculated at 12.9 percent. The total cumulative project error is 41.2 percent.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	5.0
Modeling Error	38.8
Sampling Error	12.9
Assumptions of Stipulated Factors	0.0
Project Total Error	41.2

Program Effectiveness

Verified savings	=	1,316 kW
Reported savings	=	1,816 kW
Realization Rate	=	72.5 percent

Project Number:	**SB5XL009**
Project Name:	**Los Angeles Valley College**

Project Overview

Project Summary

The Los Angeles Valley College project included lighting and HVAC retrofits designed to reduce peak electrical demand. The total demand savings were estimated at 0.433 MW with an incentive of $108,250.

Key Participants

The Los Angeles Community College District, through a competitive process, selected CMS Viron Energy Services (Viron) to provide turnkey energy related facility improvements. In addition to the project technical analysis and implementation, Viron provided project cost and savings guarantees, and project financing assistance.

Technology Overview

The campus-wide efficiency retrofit program included three main stages: (1) a compact fluorescent lighting retrofit, (2) a thermal energy storage (TES) system and central chilled water plant, plus new boilers, and (3) direct-digital controls (DDC) system.

For this project, the existing central boiler plant was decommissioned, and the plant building was renovated to include both a chiller room and a boiler room. The previous boiler produced steam, which was piped to various campus buildings through an underground pipe system. The new boiler produces hot water. The pipes previously used for steam distribution were upgraded for chilled water distribution, and new piping was installed for hot water distribution. All pneumatic controls were converted to a central DDC system.

The retrofit included eleven buildings that had pre-existing cooling systems that were displaced by the new central chilled water plant and thermal energy storage system. There were an additional four buildings that did not previously have central cooling which are now served by the central chilled water plant. Of the buildings with pre-existing cooling, five had obsolete systems that were completely removed. The other six buildings received HVAC retrofits in 1999 and 2000, and were equipped with Trane air-cooled chillers. These newer units were left in place and can be use if the central chilled water plant fails.

In total, eighteen buildings (all large, permanent structures) were included in the central plant/DDC upgrade. For the lighting retrofit, every campus building was involved. The retrofit consisted of changing out T-12, magnetically ballasted fixtures, with T-8 electronically ballasted fixtures. In addition to the eighteen main buildings, the lighting retrofit included approximately forty bungalow-type buildings installed as temporary structures in the late 1940s; these buildings did not receive DDC or HVAC upgrades.

Evaluation

Monitoring and Evaluation Procedures

Viron provided peak demand savings estimates in their original application. Estimates were based on the Trace 700 simulation model, a comprehensive whole-building energy simulation tool designed by Trane. Nexant endorses the use of this software as an approved M&V method for calculating verified demand savings.

Pre-existing chiller systems at 10 campus buildings were inspected during a pre-installation tour of the campus. All relevant information is summarized below in Table 1:

Table 1: Pre-Installation Inspection Notes, May 9, 2001

Building Number/Name	Chiller Information
16/Math/Science	Outdoor air-cooled chiller installed 2000. Trane model #RTAA0804XL01A3DOB
15/Business/ Journalism	Outdoor air-cooled chiller installed 2000. Trane model #RTAA0804XL01A3DOB
Chemistry	Outdoor air-cooled chiller installed 2000. Trane model #RTAA0804XL01A3DOB
Physics	Outdoor air-cooled chiller installed 2000. Trane model #RTAA0704XL01A3DOB
Engineering	Outdoor air-cooled chiller installed 2000. Trane model #RTAA0904XL01A3DOB
Administration	Outdoor air-cooled chiller about 20 years old. Carrier model #30GA105400AA
12/Theater Arts	Outdoor air-cooled chiller installed 1999. Trane model #CGAFC604ACA1000000
13/Music	Served by 10 small gas-fired absorption chillers installed in 1972. Only 2 are working at this time.
18/Campus Center	Served by 30-year old Carrier centrifugal units, one in use and one for back-up
Library	Served by 6 DX split systems and several packaged units

Nexant staff completed a post-installation inspection on March 27, 2002. All pump nameplate data for the installed chiller plant is summarized below in Table 2:

Table 2: Post-Installation Pump Motors Nameplate Data

Pump Purpose	Make	Model	Horsepower	Efficiency
Condenser Water*	Baldor Super-E	EM2531T	25	94.1%
Chilled Water*	Baldor Super-E	EM2543T	50	94.5%
Glycol Circulation	Baldor Super-E	EM2535T	30	94.1%

* Have Variable-Speed Drive Motors

All compressor nameplate data is summarized below in Table 3:

Table 3: Post-Installation Chiller Compressors Nameplate Data

Compressor	Make	Model	MAWP	MDMT
1	McQuay International 41691	C3616TLYY2RA	225 psi @ 250 F	20 F @ 225 psi
2	McQuay International 41689	E3616TE2RA	180 psi @ 180 F	20 F @ 180 psi

The frame-and-plate heat exchanger was a Laval Model MX25-BFG.

Program Savings

Verified peak demand savings impacts are approved as submitted by Viron; this is based on Nexant's review and approval of the Trace simulation model. Verified peak period demand savings are equal to 433 kW.

Error Analysis

Nexant identified two sources of error for this project: (1) modeling error of 15 percent using an uncalibrated Trace 700 simulation model, and (2) 15 percent error for stipulations of unknown parameters in the Trace 700 simulation model.

Table 4: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	15.0
Sampling Error	0.0
Assumptions of Stipulated Factors	15.0
Project Total Error	21.2

Program Effectiveness

Verified savings = 433 kW
Reported savings = 433 kW
Realization Rate = 100.0 percent

Project Number:	**SB5XL027**
Project Name:	**EBMUD Wastewater**

Project Overview

Project Summary

The East Bay Municipal Utility District (EBMUD) proposed to install new equipment and make modifications at their Main Wastewater Treatment Plant (MWWTP) to improve the system efficiency. The total demand savings were initially estimated at 0.224 MW, for a contracted savings of $22,400.

Key Participants

Dennis Diemer and Vince De Lange, of EBMUD, are the authorized representatives on the application form.

Technology Overview

The EBMUD Main Wastewater Treatment Plant is a high purity oxygen activated sludge treatment plant with an average flow of 80 million gallons per day (MGD). The secondary treatment process utilizes eight aeration reactor trains, each divided into four equal stages, to remove contaminants from the wastewater stream. Stages 1 and 2 are equipped with 100-hp surface aerators, which promote oxygen transfer and biological activity in the reactor trains. Typical plant operation requires six aeration reactors in service with the mixers in all four stages operating continuously.

This project included conversion of the first stage on each reactor train to an anaerobic "selector" compartment. Installation of the selector compartment was necessary to help control the growth of filamentous organisms which hinder the solids separation process in the secondary clarifiers, which are located immediately downstream of the aeration reactors. The selector compartment is anaerobic, meaning that oxygen is no longer fed to this stage for mixing with the incoming wastewater.

This project included the replacement of two 100 hp surface aerators with two 25 hp submerged mixers on reactor trains 1 and 2. The smaller mixers are designed to provide more uniform mixing and efficient oxygen transfer in the selector compartment, while requiring less power than the previous surface aerators.

Evaluation

Monitoring and Evaluation Procedures

Project savings were determined via EBMUD's reported metered demand data; consequently, the M&V effort for this project consisted of validating the accuracy of EBMUD's onsite data collection system.

Nexant installed portable Hobo data loggers on reactors #3 and #5 for a period of approximately three months. While the loggers were placed on reactors #3 and #5, the actual motor retrofits occurred at reactor trains #1 and #2; this choice was deliberate as the monitoring was performed to verify the accuracy of EBMUD's onsite data collection system, and not the demand load for any specific aeration motor. The monitored kW power data was compared to similar data from the same period collected using EBMUD's onsite data collection system. Nexant's review of the two independently recorded data sets confirmed the accuracy and validity of EBMUD's onsite data collection system. Results of Nexant's M&V monitoring activities are presented in Table 1 below:

Table 1: Average Daily kW Power Demand, Reactor Trains 3 & 5.

	Reactor Train 3		Reactor Train 5	
Date	EBMUD DDC Average kW	HOBO Average kW	EBMUD DDC Average kW	HOBO Average kW
Daily Averages	89.7	89.1	83.9	84.0

*Monitoring was performed from September 20 to December 4, 2001.

Program Savings

Nexant's M&V efforts confirmed the reliability, validity, and accuracy, to within less than one percent, of EBMUD's data collection system and allowed approval of the reported demand savings. The verified demand savings are approved at 0.0896 MW.

Error Analysis

Due to the extremely high correlation between Nexant's power monitoring and EBMUD's data collection system, modeling error is minimal, and assumed at 5 percent. Instrumentation error of 2 percent is applied to EBMUD's data acquisition system.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	2.0
Modeling Error	5.0
Sampling Error	0.0
Assumptions of Stipulated Factors	0.0
Project Total Error	5.4

Program Effectiveness

Verified savings = 89.6 kW
Reported savings = 89.6 kW
Realization Rate = 100.0 percent

Project Number:	**SB5XL034**
Project Name:	**EBMUD Aqueduct**

Project Overview

Project Summary

The scope of this project included installation of a concrete weir in order to more equally distribute the hydraulic gradient on the East Bay Municipal Utility District's (EBMUD) raw water aqueduct. This weir was designed to reduce peak electricity demand from two of the three 2,500 hp rated pumps. This weir was installed next to the existing Lafayette Aqueduct #1 concrete weir. The total demand savings were reported at 2.163 MW with an incentive of $540,750.

Key Participants

Michael Wallis, of EBMUD, served as the representative on the application form. Diosdado Hernandez, EBMUD Associate Electrical Engineer, met with personnel from Nexant and the Energy Commission during the pre- and post-installation inspections.

Technology Overview

Working together, pumps and weirs maintain the desired pressure in a pipe. A pump increases the pressure mechanically, while a weir raises the pressure by creating a pressure gradient (height differential). For this project, a weir in the Lafayette Control Center was constructed so that two pumps in the Mokelumne Aqueduct could be taken off-line for June and September (the pumps remain operational in July and August). The pumps, Westinghouse 2500-hp, have an average power demand of 2 MW each.

Evaluation

Monitoring and Evaluation Procedures

EBMUD provided detailed peak demand savings calculations in their original application. Nexant's M&V efforts consisted of pre- and post-installation inspections, as well as due diligence review of the peak power savings calculations that were submitted by EBMUD.

Verified savings are based on the assumption that the new weir will reduce the need for mechanical pumping during the months of June and September, thereby allowing the two 2500-hp pumps to be shut down during those months.

Nexant also conducted pre-and post-installation site inspections to confirm the condition of existing and installed equipment. During the pre-installation inspection, Nexant verified pump-motor electrical demand based on nameplate data and utility billing data from EBMUD. Pump motor voltage and current ratings were too high for direct measurement and monitoring by Nexant staff.

Program Savings

Peak demand savings were calculated by comparing the pre-and post-installation operating conditions, meaning the difference between the two pumps operating at full load June through September versus the two pumps operating at full load only during July and August.

Equation 1: $$kW_{AvgPeak} = \frac{(kW_{Peak}) \times (Runtime_{Peak})}{(TotalDays_{Peak})}$$

Where:

$kW_{AvgPeak}$ = average peak demand (kW)
$Runtime_{Peak}$ = number of days pumps operate during peak period (days)
$TotalDays_{Peak}$= total number of days during peak period (days)

The number of non-holiday weekdays during peak period is 83 (June thru September). The number of non-holiday weekdays during which the two pumps operate in the post-installation case is 44 (July and August only).

Table 1: Project Statistics

	Pre-Installation	Post-Installation
Number of operating days	83 days	44 days
kW of two 2,500-hp pumps	4,080 kW	4,080 kW

Using Equation 1 above:

$$kW_{PreAvgPeak} = \frac{(4080kW) \times (83days)}{(83days)} = 4080kW$$

$$kW_{PostAvgPeak} = \frac{(4080kW) \times (44days)}{(83days)} = 2163kW$$

Verified peak demand savings are then: $4080kW - 2163kW = 1917kW$.

The above demand savings are an average for non-holiday summer weekdays, June through September. The actual observed demand savings will vary depending on the month. During the months of July and August, no peak load demand reductions occur.

However, during June and September, the actual peak load demand reduction is 4.080 MW. EBMUD's reported demand savings were based on average peak load reduction.

Error Analysis

Two sources of error were identified for this project: (1) 8 percent for the assumption that power demand for the two pump motors is constant, and (2) 15 percent for stipulation that the two pumps will be turned off in June and September.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	8.0
Sampling Error	0.0
Assumptions of Stipulated Factors	15.0
Project Total Error	17.0

Program Effectiveness

Verified savings = 1,917 kW
Reported savings = 2,163 kW
Realization Rate = 88.6 percent

Project Number:	**SB5XL037**
Project Name:	**State Center Community College District**

Project Overview

Project Summary

The State Center Community College District (SCCCD) project originally included three retrofits. These retrofits were to be installed at Fresno City College and Reedley College campuses. The planned retrofits were: (1) replacement of existing centrifugal chillers with new high efficiency air conditioning units, (2) installation of a thermal energy storage (TES) system, and (3) a lighting efficiency retrofit. The project had a contract goal of 1.333 MW, with a contracted savings of $333,250. Ultimately, State Center Community College District eliminated the TES system from its work scope.

Key Participants

Brian Speece and Carl Simms were the primary contacts for the SCCCD. CMS Viron was the contractor that performed the work associated with the retrofit. The primary point of contact at CMS Viron was Greg Coxsom.

Technology Overview

The lighting retrofit consisted of converting all fluorescent fixtures from T-12 magnetically ballasted fixtures to T-8 electronically ballasted fixtures. In addition, other incandescent lighting was replaced with compact fluorescent lighting. Exit signs were retrofitted with LED lighting fixtures.

Evaluation

Monitoring and Evaluation Procedures

Nexant's M&V efforts included lighting schedule monitoring with Hobo data loggers at the two college campuses. Nexant monitored operating hours of lighting for classrooms, hallways, private offices, and administrative offices. Annual operating hours were established for these fixtures, including operating hours during the summer peak demand period.

Nexant performed post-installation inspections to verify fixture types and quantities in various locations, including those where lighting loggers were installed. Observed lighting was compared with the retrofit lighting schedules supplied by CMS Viron in order to verify the accuracy of Viron's submitted lighting tables.

The loggers monitored light fixture operating hours during regular school session (April 18 – May 25, 2002) and summer session (May 25 to August 15, 2002). The relative number of regular session and summer session days within the summer peak period were taken into account. Lighting operating hours, as determined per monitoring results, were compiled to develop a peak demand savings coincident factor. To calculate the total summer peak demand reduction, this coincident factor was multiplied by the total change in lighting load as calculated by Nexant from the lighting equipment tables for both the Reedley and Fresno State College campuses. It was assumed that all usage groups experienced a similar peak demand savings coincident factor.

The following equations were used to calculate the realized demand savings for this project:

On-peak use (%) = Peak period on hours / Total hours during peak period

Weighted kW (%) = kW_{line} / $kW_{total\ lines\ monitored}$

$(\text{Coincident use})_{line}$ = $(\text{On-peak use }\%)_{line}$ x $(\text{Weighted kW percent})_{line}$

Coincident peak use factor = $\Sigma(\text{On-peak use percent})_{line}$ x $(\text{Weighted kW percent})_{line}$

Realized kW = Total kW Saved x Coincident Peak Use factor

Program Savings

Based on the lighting equipment tables, peak power demand savings were calculated as 230 kW at Reedley and 460 kW at Fresno State Center. Based on monitoring results, Nexant determined a coincident use factor of 0.49 during the summer peak period. This atypically low coincident factor results from the fact that many of the retrofitted spaces were classrooms, which generally have lower coincident rates than normal office space, especially during summer months. Thus, the total realized savings during the peak period for this project are equal to 338.1 kW.

The interactive cooling effects realized from the decrease in lighting demand correspond to kW demand savings during the peak period of 33.8 kW. This number was calculated by multiplying the realized lighting peak load reduction by a default value of 10 percent for demand reductions resulting from lighting-HVAC interactive effects.

Thus, the total peak period demand savings realized by the lighting retrofit are equal to 371.9 kW.

This project also included a Phase II HVAC measure involving chiller retrofits at the City College campuses in Fresno and Reedly, California. Total demand savings for chiller retrofits at each campus were originally calculated at 390 kW in the project application submittal, based on the installation of a 350-ton chiller at City College in Fresno, and the installation of a 300-ton chiller at City College in Reedley. During follow up reporting, Nexant determined that the Reedley Phase II measure was never implemented.

Chiller peak demand savings were calculated from the difference between the baseline system efficiency (1.2 kW/ton) and the new chiller system efficiency (0.6 kW/ton). Nexant's verified peak demand savings for the Phase II HVAC measures is calculated at 210 kW.

A thermal energy storage (TES) measure was also included in the original application scope. However, the TES measure was never implemented; no peak demand savings are associated with the TES measure.

The State Center Community College District project resulted in a total verified peak demand savings of 581.9 kW.

Error Analysis

The on-peak use per fixture was determined from monitoring operating hours during a finite period. Fixture wattage error was assumed to be 5.0 percent. In addition, a 5.0 percent assumption error was incurred for extrapolating the logging period to the entire summer school operating schedule. The coincident peak use factor standard error was calculated to be 3.6

percent. Sampling error was calculated to be 9.0 percent. In addition, an extrapolation error of 20.0 percent was attributed to the uncertainty in applying the monitoring/calculation methodology to all line items associated with this project. The total error associated with this project is demonstrated below (the modeling error value of 6.2 percent was calculated from the 5.0 percent logging period error and the 3.6 percent coincident peak use factor error).

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	5.0
Modeling Error	6.2
Sampling Error	9.0
Assumptions of Stipulated Factors	20.0
Project Total Error	23.3

Program Effectiveness

Verified savings	=	581.9 kW
Reported savings	=	480.0 kW
Realization Rate	=	121.2 percent

Project Number:	**SB5XL039**
Project Name:	**Smart and Final, Inc.**

Project Overview

Project Summary

Smart and Final, Inc. is a foodservice and warehouse grocery company with 230 stores in seven states and northern Mexico. The project submitted to the Energy Commission proposed the installation of a computer process controls (CPC) system at all of the 151 stores in California. The new control system enables the implementation of five different measures to achieve demand reductions during peak period. These measures included:

- Reduction of the total lighting by 50 percent during peak period
- Increase of space temperature set point by 4ºF during peak period
- Increase of refrigeration compressor suction temperature by 3ºF
- Installation of variable speed drives on refrigeration evaporator fans
- Use of a new control system to cycle anti-sweat heaters on freezer doors

The original contract dated March 14, 2001 included a savings goal of 5,050 kW, with an incentive of $250/kW. The contracted incentive budget was $1.26 million. The Energy Commission reviewed the demand savings estimates and found them to be too high. Subsequently the savings goal was reduced to 2,500 kW with $457,171 in incentives.

Key Participants

Don Page – Honeywell H&BC Services, conducted initial store surveys

Bill Jackson – Honeywell Project Manager, was responsible for installing control systems

Rich Rogan – Honeywell T.E.A.M. Services representative for the Pomona store

John Kosinski – Smart and Final corporate VP in charge of construction and purchasing

Ron Felix- Smart and Final maintenance supervisor

Adel Suleiman – Energy Commission

Technology Overview

Honeywell installed a control and monitoring system by Tridium Niagra and Atrium Energy. This system enabled Smart and Final to reduce and monitor their energy use. The control system has three basic parts: (1) lighting, (2) refrigeration, and (3) HVAC.

Honeywell has servers at their corporate headquarters that run the control and monitoring systems and the enterprise-wide system "front-end", from which users can track energy use and modify system control parameters such as remote lighting and cooling set-point levels.

All control systems at each Smart & Final store were wired to an in-store Tridium/Honeywell Web central hub, which is connected to the front-end LAN (Atrium) and finally to the Internet (via Atrium software). The following is a description of each measure:

Lighting curtailment during peak period

The new Smart and Final control system has been designed to automatically turn off 50 percent of the stores' lights during the summer peak period. Honeywell has installed the required hardware so that pre-determined lighting fixtures can be turned off, for any required period of time, from the control system front-end.

Temperature setback on HVAC by 4º F during peak period

Smart and Final control system has the capability of automatically increasing the space temperature setpoint from 72 ºF to 76 ºF during the summer peak period. Honeywell installed the hardware at each store and programmed the front-end so that this occurs automatically.

Reset suction temperature on refrigeration compressors by 3ºF

Honeywell installed controls to raise the suction temperature on the refrigeration compressors so that the refrigerated-case temperatures can float up a few degrees and rely on thermal mass to save demand.

Installation of VSDs on evaporator fans

The CPC monitors the refrigeration loads and controls VSDs so that fans can modulate below 100 percent during summer peak demand periods.

Reduce anti-sweat heater load

Anti-sweat heater controls are connected to the CPC. The controls allow for cycling of the anti-sweat heaters based on a humidity reading from an installed humidistat.

Evaluation

Monitoring and Evaluation Procedures

Approximately 75 percent of project demand savings resulted from lighting and HVAC measures. The primary evaluation of the project's claimed demand reductions focused on these two measures. Nexant's M&V efforts included pre-and post-installation site inspections to determine the accuracy of the claimed kW reduction. Nexant staff verified the control system installation and constructed an EQUEST model to predict demand reduction from the lighting and HVAC measures at a typical Smart and Final Store.

Pre-installation site inspections: Nexant staff conducted pre-installation site inspections at store #329 and store #449. At the time of the pre-installation inspection, neither store had yet installed the controls described above.

Post-installation site inspections: Nexant conducted post-installation site inspections at stores #325, #301, #389, and #418. At the time of the post-installation inspection, all stores had installed the controls described above.

At store #389, summer peak demand reduction mode was simulated. Approximately 50 percent of the overhead lights, and 100 percent of the refrigerated-case lights, were turned off. In addition, the open-air freezers and coolers were also shut off. A small section of the overhead lights did not go off because of a wiring problem.

Demand Reduction Quantification:

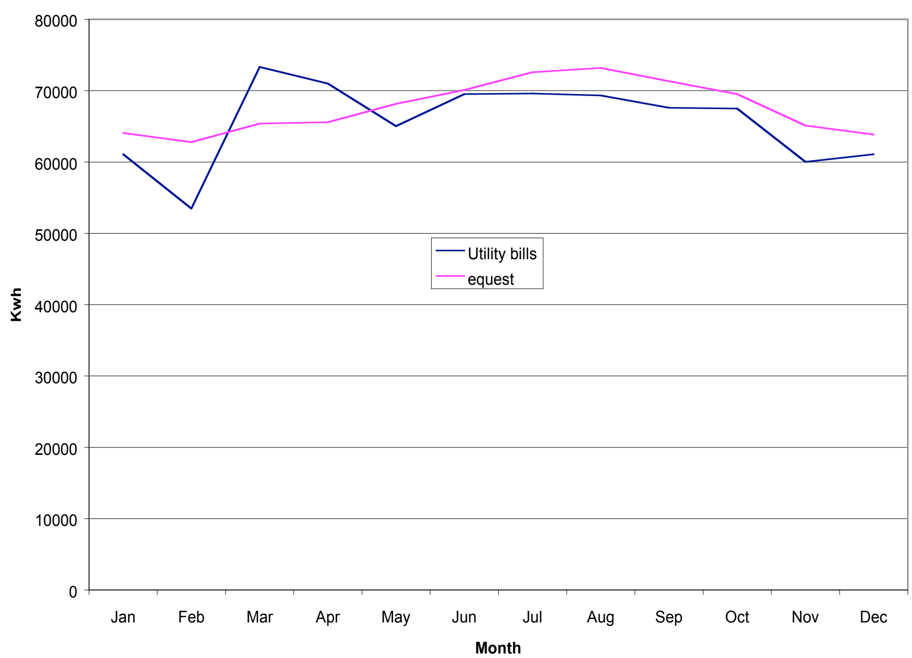
To assess the demand reduction associated with the lighting and HVAC measures, Nexant constructed an EQUEST model to predict pre-and post-retrofit peak-period energy consumption at a typical participating store. The store chosen was Store #308 in

Pomona, California. Smart & Final sent Nexant architectural prints, refrigeration data, electrical plans, and electric utility data for store #308.

EQUEST models energy efficiency measures using a graphic results display module and a simulation engine derived from the latest version of the DOE-2 building energy use simulation program. Information contained in the submitted store plans was used to run the EQUEST model. Nexant also executed a spreadsheet analysis to model energy usage parameters that could not be modeled with EQUEST.

Nexant added the results of the spreadsheet analysis to the EQUEST simulation results to arrive at total energy usage for the store. This total was compared to the store's utility bills. Parameters for both the spreadsheet model and EQUEST model were corrected to match the total energy usage as calculated from utility bills.

Figure 1: Utility Bills versus Energy Savings Simulation



Acceptable limits and criteria were used for judging model calibration, as specified in the 1999 California Non-Residential Performance Contract Program. Store #308 model error figures are in Table 1 below.

Table 1: Equest Model Calibration

	Store #308 Simulation	SPC Program Acceptable Tolerances
ERR_{month}	13.80%	15.00%
ERR_{year}	6.17%	10.00%
C_V(RMSEmonth)	6.85%	10.00%

Additional information about whole building level calibration with monthly data can be found in California's 1999 LNSPC Program Procedures Manual, page 145.

Once Nexant had calibrated the model, the predicted summer peak demands of all electrical loads were summed to arrive at a peak period power demand baseline for Store #308. EQUEST input parameters were changed to simulate the lighting measure, and the model was run to calculate peak-period post-installation electrical power demand. The lighting model input parameters were adjusted to better simulate the energy consumption of both the lighting and HVAC measures. Table 2 shows energy savings and demand savings associated with each measure as predicted by EQUEST.

Table 2: Energy & Demand Savings as Predicted by EQUEST

Arithmetic	Predicted Savings Measure	Peak Period kWh/yr Savings	Hours in Peak Period	Peak Period Reduction (kW) Store #308	Peak Period Reduction (kW) 17,500 ft^2 Store
Baseline run - Lighting measure run	Lighting	3,839	340	11.3	15.9
Lighting measure run - lighting and HVAC measure run	HVAC	4,490	340	13.2	18.6

Store #308 has a floor area of 12,447 ft^2. According to Smart and Final, the average floor area for all Smart and Final Stores is 17,500 ft2. The ratio of (17,500/12,477) was multiplied by the predicted kW reduction of each measure to arrive at a predicted kW reduction for an average size store.

Table 3: Measure Demand Savings

Measure Description	ECM #	kW reduction-proposal	kW Reduction Accepted by CEC	kW reduction Verified	Number of Stores Proposed	Number of Stores Verified	Total kW Reduction Proposed	Total kW Reduction Verified	Measure Realization Rate
50% reduction in peak period lighting	1	13.13	9.14	15.9	151	151	1379.9	2397.1	174%
4 degree set up for space temp	2	4.81	3.35	18.6	151	151	506.0	2803.6	554%
3 deg F suction temperature reset	3	0.67	0.47	0.47	151	151	70.5	70.5	100%
VFDs on evaporator fans*	4	0.67	0.47	0.47	151	151	70.5	70.5	100%
Anti sweat heaters*	5	4.50	3.13	3.13	151	151	473.1	473.1	100%
Totals		**23.8**	**16.6**	**38.5**			**2500.0**	**5814.8**	**233%**

*Not verified

Calculations used to predict demand reduction for the three non-verified measures were checked for accuracy, and information collected from pre- and post-installation site inspections was used to check assumptions in the calculations. Below is a description of calculations used, and Nexant's resulting conclusions.

Measure: 3º F reset of suction temperature on Refrigeration Compressor

Equation used in calculations for this measure:

$$kW\ reduction$$
$$= \left(\frac{30\,\text{HP of Refrigeration Compressors}}{17{,}500\ ft^2\ store} \right) \cdot \left(\frac{0.746\,kW}{HP} \right) \cdot \left(3\,{}^\circ F\ \text{Reset} \right)$$
$$\cdot \left(\frac{1\%\ \text{decrese in Compressor kW}}{1\,{}^\circ F\ \text{Reset}} \right) = 0.67\,kW\,/\,store$$

The table below compares the assumed refrigeration hp/store area used in the calculation with those stores for which Nexant verified installed refrigeration compressor horsepower.

Refrigerator Compressor hp/ store ft^2			
Metric used in Calculation	Store 308	Store 389	Store 301
0.0017	0.0047	0.0038	0.0027

Verification of percent kW reduction/ºF reset and actual 3ºF reset were not preformed. However, Nexant believes the values are conservative.

Measure: VFDs on evaporator fans

Equation used in calculations for this measure:

$$kW\ reduction$$
$$= \left(\frac{4.5\ \text{HP of Evaporator Fan}}{17{,}500\ ft^2\ store} \right) \cdot \left(\frac{0.746\,kW}{HP} \right) \cdot \left(20\%\ reduction\ in\ kW \right)$$
$$= 0.67\,kW\,/\,store$$

The table below compares the assumed evaporator fan hp/store area used in the calculation with those stores for which Nexant verified installed evaporator fan horsepower.

Evaporator Fan hp/ store ft^2			
Metric used in Calculation	Store 308	Store 389	Store 301
0.0003	0.0005	0.0002	0.0004

In order to achieve a 20 percent reduction in fan input power, a VSD must reduce fan airflow by 10 percent of rated maximum airflow[1]. This airflow reduction target is reasonable for refrigeration evaporator fans. During the post-installation site inspection of store #389, the rotation of fan blades were slower for evaporator fans controlled by VFDs.

Measure: Anti sweat heaters

Equation used in calculations for this measure:

$$kW\ reduction$$
$$= \left(\frac{25\text{ freezer doors}}{17{,}500\ ft^2\ store}\right)\cdot\left(\frac{3\,amps}{freezer\ door}\right)\cdot(120\,volts)\left(\frac{kW}{1000\,watts}\right)\cdot(50\%\,reduction\,in\,kW)$$
$$= 4.50\,kW\,/\,store$$

The table below compares the assumed number of freezer doors/store area used in the calculation with those stores for which Nexant verified the quantity of freezer doors. The table shows that the metric used in the calculation is reasonable.

Freezer doors/ store ft^2			
Metric used in Calculation	Store 308	Store 389	Store 301
0.0014	0.0021	0.0013	0.0023

The table below compares the assumed number of amps per freezer door used in the calculation with stores for which Nexant verified the number of installed freezer doors.

Amps / door			
Metric used in Calculation	Store 308	Store 389	Store 301
3.0000	2.3440	2.5000	2.4133

Smart and Final is cycling their anti-sweat heaters. The percent reduction is equal to the duty cycle imposed on the anti-sweat heaters by the new control system.

Error analysis

Nexant performed error analyses for the HVAC and lighting measure demand savings. For each of the two measures, error was introduced into the analysis as follows: Equest error (modeling error), error in normalizing results for store #308 to the average 17,500 square foot store (sampling error), and error associated with extrapolating verified data to the 151 stores involved in the project (assumption of stipulated factors). Table 4 shows the cumulative error results associated with each measure.

1 United States Environmental Protection Agency (EPA), Energy Star Buildings Manual. EPA 430-B-95-007, July 1995, Figure 4.1.3-2, page 4-16.

Table 4: Error Analysis

Source of Uncertainty	Lighting	Non-lighting (HVAC)
Instrumentation Error	0.0	0.0
Modeling Error	13.8	13.8
Sampling Error	3.0	5.0
Assumptions of Stipulated Factors	7.0	10.0
Total Measure Error	15.8	17.8

Program Effectiveness

Verified savings = 5,814.8 kW

Reported savings = 2,188.0 kW

Realization Rate = 265.8 percent

Project Number:	SB5XL044
Project Name:	Johns Manville

Project Overview

Project Summary

Johns Manville specializes in the manufacture of building insulation and roofing materials.

This project consisted of four measures.

1. Motor downsizing. Seventeen 5-hp motors were downsized to ¾-hp.
2. Temperature controls on melter hoods. Temperature sensors that operate in conjunction with variable speed drives were placed on previously manually operated melter hoods.
3. Insulation on melter hoods. Insulation was installed on six melter hoods.
4. Compressed air demand reduction. Multiple measures allowed one 700-hp air compressor to be taken out of service.

1.394 MW in savings was initially contracted. The incentive associated with this project was $230,750.

Key Participants

Johns Manville's Willow Plant Engineering and Maintenance staff was responsible for all aspects of this project, including management, engineering, installation, and maintenance. Mr. Tom Cianelli, Plant Engineer, manages staff. Corporate Engineering and Energy Resources staff supported the group when necessary.

Technology Overview

Motor Downsizing

Seventeen vacuum motors are utilized in the packaging process. Previously, they were grossly oversized at 5 hp each. The motors power vacuums used in the packaging process. These motors were downsized to ¾ hp.

Temperature Controls on Melter Hoods

During the melting process, sand is fed into the melter by a metering auger, which is run by a 5 hp motor equipped with a VSD. The motor's VSD is currently controlled by a hand-tuned potentiometer. Inside the melter, there is a gradient of temperatures, from the bottom which is mostly molten glass to the top, where a layer of un-melted sand shields the melter from the extreme radiant energy losses that occur when the molten glass is left open to the melter's hood. Brian Warthen of Johns Manville reported that approximately five times per day in each of the six melters, the temperature and consistency of the material in the melter become such that the top layer of sand burns off, exposing the hood to the extreme heat of the molten glass. A great deal of energy is lost at these times due to radiant heat losses. If the metering augers were better able to control the amount of sand being fed into the melters at any one time, the problem would be mitigated. Consequently, the project included the installation of temperature sensors in the melter hoods. The amount of sand being fed into the melters is automatically controlled by the

VSDs, which are in turn controlled by the temperature sensors. The Energy Commission funded two melter hoods as part of this retrofit.

Insulation on Melter Hoods

Additional insulation was installed on six melter hoods.

Compressed Air Demand Reduction

This measure involved a number of sub-measures that resulted in a reduced demand for the 90-PSI rated compressed air provided by the air compressors.

The first sub-measure involved the facility's dust filter. Previously, the filter was continuously cleaned by a series of "air bars" (air bars are pipe headers with holes drilled into them where the air escapes) that delivered pulses of air to clear dust from the filter. The project included installation of a differential pressure sensor, which controls the air bars so that they operate only when needed, rather than continuously.

The next four sub-measures involved air bars that were used for some part of the manufacturing process. Previously, the air bars were supplied with air by the central compressed air system; however, they did not need the amount of air pressure provided by the central system. These air bars were converted from the central system compressed air to distributed, low-pressure, high volume compressed air supplied by small motors.

Another sub-measure involved the conveyor belt cleaning system. The system previously used high-pressure air bars to clean and dry a conveyor belt of scrap insulation on the return part of its cycle. The air bar was converted to a low-pressure air knife.

Another sub-measure involved the conversion of an air bar to a low-pressure blower system where it's needed to keep the insulation from sticking to a roller. Another air bar that kept the insulation inside the desired track on the conveyor belt was converted to a low-pressure blower system. A final air bar to blower system conversion was made where compressed air is used to trim the edges from the finished product on the production line.

Lastly, two sub-measures involved the conversion of a high-pressure air/water spray system to a low-pressure water atomizer.

Previously, there were 5 active 700-hp compressors with a 6th serving as backup. With the compressed air reductions that resulted from this project, the facility was able to go down to 4 active compressors with a 5th serving as backup.

Evaluation

Monitoring and Evaluation Procedures

Nexant's M&V efforts included two pre-installation inspections, a post-installation inspection, detailed heat transfer calculations, pre- and post-installation real time power monitoring on all air compressors, and all other measurements and calculations necessary for verifying the summer peak period power reduction for all project measures.

Motor Downsizing--Engineering calculations were employed. Seventeen motors downsized from 5-hp to ¾ hp. It was assumed that the motors operate 8760 hours per year.

Temperature Controls on Melter Hoods--This measure involved the installation of automatic variable-speed drive controllers on feed augers serving two of the facility's electric melter hoods. Controller data was available, including melter hood temperature and feed auger material flow. Melter hood temperature data was recorded before the installation of the measure, and similar data was recorded after the installation. These two data sets were compared, and a combination of this data and engineering heat transfer calculations were used to determine savings.

Insulation on Melter Hoods—Heat transfer engineering calculations were used to calculate savings for this measure.

Compressed Air Demand Reduction--Previously there were 5 active compressors with a 6th serving as a backup. With the compressed air reductions from this project, the facility was able to go down to 4 active compressors with the 5th serving as a backup. These compressors are controlled by an Ingersoll-Rand motor control system that can be used to monitor and record operational data. The existing control system was used to monitor the compressors so that the facility's processes were not interrupted by the installation of another monitoring system. Data was recorded on a laptop computer at 15-minute intervals for one week prior to the installation of measures, and then again for one week after the installation of measures. The two data sets were compared to determine peak demand savings. Nexant performed regressions of compressor power draw against ambient air temperature and compressor airflow to better estimate savings. There are seven controllers, one for each of the six compressors and one master controller that runs the others. Data was collected from the master controller box. Each of the six compressor-controllers has 8 analog inputs. The DOS program used for monitoring could record a large number of parameters, including kW power draw, flow, temperature and pressure. Final compressed air demand reduction savings were calculated from monitored data for average kW power draw for all active air compressors, including adjustments for additional low-pressure blowers and ambient air temperatures.

Program Savings

Table 1: Contracted and Verified Savings

	Contracted Savings (kW)	Verified Savings (kW)
Motor Downsizing	29.8	53.9
Temp Controls on Melters	22.0	22.0
Insulation on Melters	300.0	300.0
Compressed Air Reduction	1041.5	547.1
Total	**1,394**	**923**

Brian Warthen of Johns Manville originally submitted the savings calculation of 923 kW for the project's peak period demand savings. John Farthing, of Air Solutions Group, assisted Brian Warthen with savings potentials and calculations.

Nexant's engineering staff worked closely with Brian Warthen, performing due diligence review in order to validate and approve all assumptions and calculations used in deriving the final demand savings figure. After careful analysis, and extended correspondence, the demand savings figure was verified and agreed upon by Brian Warthen, Nexant engineering staff and Adel Suleiman of the Energy Commission.

Error Analysis

The total project error is significant because the four main measures involved a total of twelve sub-measures which each contributed its own uncertainty. Each of the four main project measures includes related instrumentation, sampling, modeling, and assumption error.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Motor Downsizing	0.8
Temp Controls on Melters	16.0
Insulation on Melters	5.3
Compressed Air Reduction	19.1
Project Total Error	25.5

Program Effectiveness

Verified savings = 923.0 kW
Reported savings = 923.0 kW
Realization Rate = 100.0 percent

Project Number:	SB5XL048
Project Name:	USA Waste of California

Project Overview

Project Summary

USA Waste of California (Waste Management (WM)) proposed to install eleven new electrical generation facilities at existing WM-operated landfills. The generators were expected to provide total peak demand reduction impacts of 14.4 MW with an accompanying incentive of $3,607,000.

Key Participants

Kent Stoddard, of Waste Management, is listed as the Authorized Representative on the IPLRP application form.

Technology Overview

The installed generation units use landfill gas (LFG) as a fuel source. The projects were designed to utilize Deutz reciprocating engines with net power capacities of 1.28 MW.

The basic configuration employed at each facility is as follows: gas is extracted from the main header of the LFG collection system and delivered to gas processing equipment. The gas processing equipment consists of a gas booster/compressor, coalescing filter to remove slugs of water, particulate filter, flow metering station, final moisture separator, condensate receiver, and condensate pumping and storage subsystem. After processing, the gas enters the engine generator set, where it is combusted. A high voltage system with transformers and switchgears steps up the 480-volt electrical output to distribution and transmission voltage.

Evaluation

Monitoring and Evaluation Procedures

The original measurement and verification plan consisted of reviewing and analyzing power production data collected via on-site monitoring systems. However, per Nexant's discussions with Frank Mazanec of WM Energy Solutions, Inc., 15-minute data monitoring was not provided because of problems with installed units, problems with the data monitoring system, and issues with well head replacements. As Nexant could not directly monitor the installed units due to their high voltages, and because the data monitoring system was beset with problems, 15-minute real power data was not available to verify demand savings during the summer peak demand period.

Program Savings

Waste Management completed installation of the proposed generation equipment at one site only, the Altamont Landfill. Two Deutz engine generator sets with rated capacities of 1.28 MW each have been installed at the Altamont Landfill site. WM reported that this installation is contributing 2.5 MW of demand reduction impacts.

Error Analysis

Since no monitoring data was available to verify the demand impacts for this project, Nexant assumed an error of 20% for the stipulation that both generation sets are operating at nameplate rated capacities during the summer peak demand period.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	0.0
Modeling Error	0.0
Sampling Error	0.0
Assumptions of Stipulated Factors	20.0
Project Total Error	20.0

Program Effectiveness

Verified savings = 2,500 kW
Reported savings = 2,500 kW
Realization Rate = 100.0 percent

Project Number:	**SB5X3002**
Project Name:	**Pure Power**

Project Overview

Project Summary

The goal of this project was to install 3.6 MW (contract incentive = $900,000) of electrical generating capacity through the installation of turbine generators using ethanol as fuel. The turbines were designed to take advantage of a substation interconnect that had previously been used for the now defunct Carver Wind Energy facility. This setup allowed the turbines to share the wind power grid interconnect facilities and infrastructure.

The project was originally submitted under the AB 970 program; however, adequate funding was not available. The Energy Commission allowed the project to be submitted and approved under the SB 5X program. The units were installed in the San Gorgonio Pass near North Palm Springs.

Key Participants

Doug Vind, the Managing Partner of Pure Power Energy Company, LLC was the authorized representative listed on the grant application, and served as the primary contact. Ralph E. Hitchcock, President of Ralph E. Hitchcock & Associates, assisted with implementation of the project, and prepared periodic status reports.

Technology Overview

The project uses turbines to produce electricity using low-grade ethanol as fuel. The turbines are approximately 20-year-old units. Seven of the nine installed generating units were manufactured by Garrett; these units have a rated nominal capacity of 560 kW. The two remaining installed units were manufactured by Solar; these units have a rated nominal capacity of 350 kW.

The low-grade ethanol is manufactured from beverage wastes, which are fermented at a facility in Rancho Cucamonga. Originally, the participant had planned to install some of the units at the fermentation facility. However, city regulatory issues and a lack of a substation infrastructure prevented this.

Evaluation

Monitoring and Evaluation Procedures

The M&V plan consisted of performing pre- and post-installation inspections at Palm Springs wind farm where the turbines were installed, in order to observe the site before and after the installation of the equipment. The nine gas turbine generating units were installed at the site as of June 2002. However, due to interconnection issues raised by Southern California Edison, the project did not come online until December 31, 2002. Test runs of the turbines were conducted in May 2002 to determine the achievable power output. The rated capacity of the units is 4,620 kW. Actual testing showed that the total achievable capacity is equal to 3,460 kW.

Program Savings

The approved savings for the project were originally based on the nameplate generating capacity of twenty-four 150 kW turbines. However, the participant installed seven 560 kW turbine units and two 350 kW units rather than the proposed units. The total tested capacity of the units is equal to 3.46 MW.

The 3.46 MW demand savings figure represents an increase in available generation capacity during summer peak period hours. The units are exposed to the elements and not expected to run on a permanent basis. In addition, for full facility operation at the test-demonstrated 3.46 MW, the facility requires approximately 850 gallons of ethanol per hour. Continuous operation at full load during summer peak demand hours requires at least one truck delivery of ethanol per day.

Error Analysis

Sources of error in the estimation of the demand savings for this project are instrumentation error and assumption error. Revenue electrical meters on the substation serving the generators were used to determine generation capacity. Error inherent in the electric meters is equal to 2 percent.

Assumption error included the consistency of turbine power production over a period of several hours. Nexant assumed that the facility would be able to simultaneously provided power from all nine generators, with rapid start up times, during summer peak periods and without downtime for maintenance. Nexant assumed the aggregate of these errors to be 20 percent. The resulting total error for the project is 20.1 percent.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	2.0
Modeling Error	0.0
Sampling Error	0.0
Assumptions of Stipulated Factors	20.0
Project Total Error	20.1

Program Effectiveness

Verified savings	=	3,460 kW
Reported savings	=	3,600 kW
Realization Rate	=	96.1 percent

Project Number:	**Energy Commission 0011**
Project Name:	**Pilgrim Towers East**

Project Overview

Project Summary

Pilgrim Towers East is an 8-story senior citizens apartment complex with meeting rooms and activity areas on the ground floor. This project involved lighting efficiency retrofits in the common areas (hallways and meeting rooms), and application of window tinting film on the west-facing side of the building. Total demand savings for the project were estimated in the application as 34.4 kW with 19.0 kW attributable to the lighting portion, and the remaining 15.4 kW for the window film. The grant was expected to be $9,750.

Key Participants

Pilgrim Towers, as the participant, referred to the LA area BOMA group for technical assistance and proposed vendor selection. Through BOMA, ASW Engineering was consulted in order to determine demand savings calculations for the window tint film. The actual tint vendor was not identified. BOMA also introduced Amtech Lighting Services as the lighting vendor and the source of demand savings calculations for the lighting retrofit portion of the project.

Technology Overview

Pre-existing T-12 fluorescent lamps, operating with conventional electro-magnetic ballasts, were removed and replaced with new high-efficiency electronically ballasted T-8 lamps on a lamp-for-lamp basis. Pre-existing incandescent *Exit* signs were also removed and replaced with LED *Exit* signs. Large sliding glass doors and other windows mounted on each apartment on the west side of the building were coated with a tint film called V-Kool. V-Kool is designed to reduce the effects of solar heat gain and its subsequent demands on centralized HVAC systems.

Evaluation

Monitoring and Evaluation Procedures

The lighting system was evaluated by performing both pre- and post-installation site inspections to verify both fixture quantities and the configurations of lamps and ballasts described in the audit. As the lighting is operated in common area hallways that lack any natural light, the stated 24-hour per day operational schedule was readily endorsed without need of monitoring. Tint film application was verified at the post-installation site inspection, as was the gross square footage of affected windows. These figures were compared with the calculations performed by ASW Engineering for accuracy and engineering precision.

Program Savings

During the course of the post-installation inspection, some inconsistencies were identified in terms of the qualitative aspects of the lighting audit. The input wattage values used for the baseline fixtures were overstated in the final draft submitted for Energy Commission review. An original copy of the lighting audit performed by Amtech's Greg Blair revealed more reasonable input wattage values based on fixture vintages and components being utilized during the baseline period. Furthermore, the original fixture wattage values reflected current minimum efficiency standards for the relevant components. While this issue affects the baseline claimed for the lighting system's demand, the proposed retrofit configurations were not accurately identified either. While the audit indicates that the predominant fixture type (a 4 foot, 2-lamp unit) is to be retrofitted with single two-lamp ballast, the vendor instead used 4-lamp ballasts that were tandem-wired between two fixtures. This alternate wiring configuration slightly affects the post-installation lighting system demand, but was not accurately identified in the audit submitted to the Energy Commission. The ballast installed was inspected and their input wattage ratings were confirmed from the manufacturer's published specifications.

The following table summarizes the differences between the demand values claimed in the project application and those that represent the accurate values as confirmed by Nexant's M&V efforts. It should be noted that the final demand savings value claimed in the application incorporates a 0.75 coincidence factor that ultimately reduces the verified demand savings to 13.3 kW from the calculated 19.0 kW.

Table 1: Claimed and Verified Demand Savings

		Claimed in Application				As Inspected			
Fixture type	Total fixtures	Watts per fixture	Total demand (kW)	Retrofit watts per fixture	Demand savings (kW)	Watts per fixture	Total demand (kW)	Retrofit watts per fixture	Demand savings (kW)
F41EE	24	55	1.32	32	0.552	43	1.032	35	0.192
F42EE	297	96	28.512	51	13.365	72	21.384	50	6.534
F44EE	95	192	18.24	98	8.93	144	13.68	100	4.18
F82EE	1	172	0.172	98	0.074	123	0.123	100	0.023
IE20/2	65	40	2.6	3	2.405	40	2.6	3	2.405
Totals	**482**		**50.844**		**25.326**		**38.819**		**13.334**

A default HVAC interactive cooling effect of 10 percent was factored into the lighting retrofit demand savings. Verified lighting demand savings were calculated at 14.7 kW.

While some inaccuracies were identified in the lighting scope of the project, the window film application was consistent with the descriptions provided to the Energy Commission, and the calculations performed by ASW Engineering were sound. Subsequently, no modifications to the demand savings attributable to the window film were required; the verified demand savings are equal to 15.4 kW.

Error Analysis

The standard deviations reported for the lighting retrofit were calculated using realization rates for each different fixture configuration for the five different types of affected units. The sampling error of 3.5 percent for the lighting measure was based on a sample size of 55 from a population of 482 fixtures. The modeling error of 17.0 percent was based on the range of discrepancies between actual and claimed lighting wattage ratings for both baseline and post-retrofit fixture types. A stipulated error of 5 percent was applied for use of standard fixture wattages. A stipulated error of 10 percent was applied for use of a default HVAC interactive factor.

The modeling error of 20 percent for the window film measure was based on the operational efficiency range of the HVAC equipment affected by the V-Kool window film. For lighting, 55 of 482 fixtures were sampled. For the V-Kool window film, all 2800 square feet of film surface was verified.

Table 2: Error Analysis

Source of Uncertainty	Windows	Lighting
Instrumentation Error	0.0	5.0
Modeling Error	20.0	17.0
Sampling Error	0.0	3.5
Assumptions of Stipulated Factors	0.0	10.0
Total Measure Error	20.0	20.6

Program Effectiveness

Verified savings	=	30.1 kW
Reported savings	=	19.0 kW
Realization Rate	=	158.4 percent

Project Number:	**Energy Commission 0020**
Project Name:	**City of Lakewood**

Project Overview

Project Summary

The City of Lakewood's City Hall facility utilizes a new 80-ton chiller configured to operate as the basis of a TES (Thermal Energy Storage) system. The chiller and its accompanying cooling tower and pumps operate at night to make ice that is stored in two new outdoor tanks. The new chiller was recently installed to replace a pair of older water-cooled condensing units, and the savings identified in the application were a combination of the retrofit of the original cooling system and the conversion to the TES system. During the day (i.e. peak period hours), only the chilled water circulation pumps are operated to distribute cooling water throughout the facility. The total demand savings were estimated at 59.5 kW with an accompanying incentive of $14,875.

Key Participants

The City of Lakewood utilized internal project management resources for project implementation and relied on a consultant, Toft Wolff Farrow, Inc., for design of the construction drawings and specifications for this project. A competitive bid was conducted within the city's list of approved HVAC contractors to determine the installation vendor. The vendor's name was not provided during the inspection; however, Trane was responsible for final commissioning of the chiller after the conversion. The City of Lakewood also contracted with Xenergy, Inc. as a program administrator. Xenergy's responsibilities included estimating peak kW savings for the project.

Technology Overview

The existing water-cooled condensing units were removed, and a new central plant operating an 80-ton chiller was installed along with all auxiliary pumps and a set of ice storage tanks. During the evening hours, the chiller, a cooling tower (with a single 7.5 hp fan motor), and two condenser-water pump motors (rated at 7.5 hp each) are operated. During the day, two new 15-hp chilled water circulation pumps are operated to distribute cooling water from the ice storage tanks throughout the facility. Along with the new central plant, a new DDC control system was installed to regulate the operation of all the affected systems, including the existing air-handlers and some new VAV boxes that were also added inside the main building.

Evaluation

Monitoring and Evaluation Procedures

While the original demand savings calculations made by Toft Wolff Farrow, Inc. indicated an estimated demand reduction of 59.5 kW, a pre-installation review of the project resulted in modifications to the estimated demand reduction based on load factors attributable to the original cooling system. Xenergy was contracted to provide peak demand savings calculations. Xenergy's peak demand savings calculations were modified based on a pre-installation review of the project, and a revised demand savings figure of 48.3 kW was derived. Reports from Xenergy were reviewed, and Nexant's pre- and post-installation site inspections confirmed the data, assumptions, and calculations used in Xenergy's peak demand savings estimates. A review of operational records and instantaneous measurements of the affected HVAC components formed the basis of Nexant's due diligence review and analysis. During Nexant's post-installation site inspection, the DDC system's terminal was consulted for operational schedules; these parameters were compared with the design submitted with the application. Ultimately, all aspects of the project were consistent with the design description and the demand savings calculations.

Program Savings

Operational parameters maintained by the site's DDC system were reviewed during the site inspections and compared with the design consultant's original study. Subsequently, the original demand reduction estimate of 59.5 kW was recalculated by Xenergy, reviewed by Nexant, and verified at 48.3 kW.

Error Analysis

Pursuant to Nexant's M&V and evaluation efforts, the following sections and accompanying table describe the magnitude and nature of error in the demand savings analysis.

Instrumentation or measurement error: Selected pre- and post-installation demand measurements for the affected pumps were recorded with the use of a Fluke Model 41B true power meter. The manufacturer's specifications identify a potential error of 1 percent for demand measurements within the relevant range.

Modeling error: An assumption regarding the loading characteristics of the baseline cooling units was used to reduce the original demand savings estimate. The loading characteristic of the original cooling units was stipulated at roughly 60 percent of full load, and this assumption is consistent with a 19 percent modeling error in terms of net kW savings attributable to the project.

Sampling error: As all the affected components were reviewed in detail as opposed to a statistical sample, no sampling error is attributed to the project.

Assumptions of stipulated factors: As the stipulated operational parameters of the new TES system were readily confirmed via the EMS program, no error for post-installation stipulated factors is appropriate.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	1.0
Modeling Error	19.0
Sampling Error	0.0
Assumptions of Stipulated Factors	0.0
Project Total Error	19.0

Program Effectiveness

Verified savings	=	48.3 kW
Reported savings	=	48.3 kW
Realization Rate	=	100.0 percent

Project Number:	**Energy Commission 0090**
Project Name:	**St. Jude Medical Center**

Project Overview

Project Summary

The St. Jude Medical Center is a hospital and series of accompanying support buildings that have been progressively modified and expanded since the first part of the facility was constructed in 1957. The project involves a comprehensive lighting retrofit of all the fixtures in the hospital and surrounding support structures. The demand savings identified in the application was 101 kW, with approximately 87 kW directly attributable to the lighting retrofit, and the remaining 15 kW claimed for interactive HVAC savings enabled by the lighting load reductions. The grant was expected to be $25,250.

Key Participants

St. Jude relied on Johnson Controls for all of the engineering audits and implementation of the project. Johnson Controls also performed the administration and preparation of all Energy Commission submittals and program participation activities.

Technology Overview

Existing T-12 fluorescent lamps operated with conventional electro-magnetic ballasts were removed and replaced with new high-efficiency electronic ballasts and T-8 lamps on a lamp-for-lamp basis. Existing incandescent *Exit* signs were also removed and replaced with new LED *Exit* signs. In some cases, original HID recessed interior fixtures were removed and replaced with new compact fluorescent units, and a small number of fixtures were de-lamped to operate with half the original quantity of lamps per fixture. Using lighting demand reduction values, Johnson Controls claimed interactive demand savings based on the reduction in cooling tons required from the site's central plant.

Evaluation

Monitoring and Evaluation Procedures

The lighting system was evaluated by performing both pre- and post-installation site inspections to verify both fixture quantities and the configurations of lamps and ballasts described in the audit. As the lighting is operated in common area hallways that lack any natural light, the stated 24-hour per day operational schedule was readily endorsed without need of monitoring. However, lighting operations in the patient rooms were scrutinized as part of the inspection process. Based on inspection results, the lighting inventory was analyzed in detail to segregate the demand savings attributable to the patient rooms from the total demand reduction figure. Inspections revealed that patient room lighting is not operated during the peak periods of 14:00 to 18:00 hours, and demand savings attributable to these areas were deducted from the total claimed for the project.

The interactive HVAC savings calculations were also carefully scrutinized and consistency with demand savings calculations was evaluated. Observations of the areas served by the central plant revealed that the central plant does not serve many areas where lights were retrofitted; the interactive savings allocated for these areas were deducted from the total. Furthermore, the fundamental requirement of the hospital's air distribution system to utilize 100 percent outside air (to mitigate nosocomial infection proliferation) reduces the validity of the interactive savings assumptions. These factors, combined with the lack of patient room lighting during peak periods, led Nexant to conclude that demand savings attributable to the interactive HVAC effects should not be included in the total verified demand savings.

Program Savings

During the course of the post-installation inspection, some inconsistencies were identified relating to lighting project completion. Several of the more significant areas of the hospital were never completed. Fixtures representing approximately 3 percent of the total demand savings for non-patient room areas were never retrofitted, and their accompanying demand savings were deducted from the total. As previously indicated, the lighting audit was analyzed in detail in order to segregate the savings attributable to patient rooms. While a total demand savings potential of 108.75 kW was identified in the audit, 28.22 kW of lighting load is in patient rooms and other areas connected with them that do not operate during the peak demand period.

Due to the fact that three percent of the retrofit to non-patient rooms was not completed, a reduction was made to the non-patient room area demand savings of 80.53 kW, yielding the value of 78.11 kW.

In addition, Johnson Controls acknowledged the use of the Energy Commission's suggested 80 percent coincidence factor in developing its claimed demand savings for the lighting retrofit. The 80 percent coincidence factor was applied to the non-patient room areas' demand savings value of 78.11 kW, in order to derive a more accurate demand savings calculation of 62.49 kW.

As previously stated, the interactive HVAC savings assumptions did not withstand the scrutiny of inspection and were deducted in total. Based on Nexant's pre- and post-installation inspection findings and review, demand savings for the project were revised. The verified demand savings are equal to 62.49 kW.

Error Analysis

Pursuant to the project's M&V and evaluation efforts, the following sections and accompanying table describe the magnitude and nature of error in the energy savings analysis.

Instrumentation or measurement error: Nexant assumed a 5 percent error for fixture wattages from the standard wattage table.

Modeling error: Nexant assumed a 10 percent modeling error for use of the default lighting coincident factor.

Sampling error: The total population of fixtures affected by the retrofit project (the N value in the sampling error calculations) is 3389, and the sample observed during the inspection (the *n* value in the calculations) is 417. Based on the review of the lighting inventories submitted with the project documents, a comparison of estimated savings versus verified lighting savings was completed and a standard deviation value of 12.26

was calculated for the project. Using standard statistical practices, a sampling error of 0.5623 was derived for the project that incorporates a finite population multiplier in observance of the known N value of 3389.

Assumptions of stipulated factors: During the post-installation review, it was determined that the operational schedules originally submitted for the lighting systems were inaccurate. However, this inaccuracy was accounted for in Nexant's calculation of verified demand savings, and is not applicable as error associated with verified demand savings.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	5.0
Modeling Error	10.0
Sampling Error	56.2
Assumptions of Stipulated Factors	0.0
Project Total Error	57.3

Program Effectiveness

Verified savings = 62.5 kW
Reported savings = 101.4 kW
Realization Rate = 61.6 percent

Project Number:	Energy Commission 0118
Project Name:	Southern California Water Company

Project Overview

Project Summary

The Southern California Water Company operates a series of wells throughout the region that collect potable water for sale to municipalities that do not operate internal water accumulation assets. The wells and pumps were aging, and new high-efficiency pump motors and accessory components would enable a more energy-efficient removal of the groundwater. The contracted demand savings for the proposed retrofits at 11 sites was 342.2 kW, with an accompanying incentive of $129,500.

Key Participants

The Southern California Water Co. used a combination of internal resources and a consultant, Rod Larsen, to administer the Energy Commission application process and overall project design and implementation. An independent third-party company, Pump Check, of Riverside California, was retained as a testing and verification agent to assist in the assessment of well and pump motor performance. Pump Check was responsible for pre- and post-retrofit analyses.

Technology Overview

Pre-existing pump motor efficiencies and sequences of operation were inefficient. New high-efficiency motors and VFDs with new controls were added to selected pumping fields in an effort to reduce inefficient or excessive pump operations and accompanying power demand.

Evaluation

Monitoring and Evaluation Procedures

Due to the submersed configuration of many of the affected pumps, conventional M&V activities and measurements were not possible. Nevertheless, Pump Check was retained by the Southern California Water Company as a resource with a unique inventory of measurement and analysis tools that were used to evaluate post-installation pump performance. Based on analyses performed by Pump Check’s technicians for all of the affected systems, a comprehensive review was possible which yielded highly accurate results that would not have been attainable with the use of conventional testing and metering equipment. Based on the detailed measurements performed by Pump Check, revised demand savings values were derived.

Program Savings

During the course of the project, several pumping sites proved to be too costly for retrofit with the proposed systems, and the scope was modified in order to exclude these systems. Furthermore, several pumping systems achieved differing levels of demand reductions based on the analyses performed by Pump Check. The original demand reduction was estimated at 342.2 kW; however, the combination of eliminated sites and varying results yielded a total of 216 kW in savings. The following table summarizes the demand reductions for all of the affected sites.

Table 1: Estimated and Verified Pump Demand Savings

Name of Pumping Site	Pump Motor Size (hp)	Estimated Demand Savings (kW)	Verified Demand Savings (kW)	Proposed Savings Realization (%)
Hawaiian	100	96.4	54.9	57
Centralia 3	30	9.6	10	104
Compton	75	65.6	29	44
McKinley	100	18.7	45.5	243
Roseton	100	14	35.7	255
Priory	75	58.6	40.9	70
Miramonte	100	10.9	0	0
Willowbrook	75	7.6	0	0
Centralia 5	75	35.3	0	0
Massinger	75	20.6	0	0
Dace	75	4.9	0	0
Total		**342.2**	**216.0**	**63%**

Based on the detailed site inspections and analyses of the revised pumping efficiency enhancements, demand savings for the project are verified at 216 kW. Only 63 percent of *proposed* savings were realized; however, the project Realization Rate is equal to 100 percent because Nexant verified all demand savings *reported* to the Energy Commission.

Error Analysis

Pursuant to the project's M&V and evaluation efforts, the following sections and accompanying table describe the magnitude and nature of error in the demand savings analysis.

Instrumentation and measurement error: As discussed in prior sections, all measurements for the project were performed by a third-party consultant, Pump Check, using specialized instruments. A review of the testing and measurement equipment used in the analysis of the project yielded a maximum potential error of 1.5 percent for the relevant range of samples recorded.

Modeling error: Calculation methodologies utilized to estimate verified demand savings are assumed to incorporate a modeling error of 15 percent.

Sampling error: As all six of the sites that were retrofitted were analyzed in great detail, no sampling error is assigned to the project.

Assumptions of stipulated factors: Nexant assumed a 10 percent error for these demand savings consistently occurring during summer peak demand hours.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	1.5
Modeling Error	15.0
Sampling Error	0.0
Assumptions of Stipulated Factors	10.0
Project Total Error	18.1

Program Effectiveness

Verified savings = 216.0 kW
Reported savings = 216.0 kW
Realization Rate = 100.0 percent

Project Number:	Energy Commission 0127
Project Name:	City of Burbank

Project Overview

Project Summary

The City of Burbank operates a wastewater treatment facility that used 1986-vintage ceramic cone-type diffusers as the basis of its aeration process. Wastewater is passed through long basins, where pressurized air is injected in order to feed oxygen to microbes that break down the waste for further chemical processing. Older systems using the ceramic cones were prone to clogging and, subsequently, required more air pressure over time in order to deliver sufficient oxygen to the waste being treated. This project involved the removal of the ceramic cones and the installation of more efficient membranous diffusers. Each diffuser is a flat disk, roughly 12 inches in diameter, which is connected to the existing pressurized air-piping network. The diffusers produce more bubbles in the wastewater and do not clog in the same manner as the cones. Subsequently, the air produced by the blowers is more efficiently distributed through the wastewater, and the absence of clogged cones results in less escalation of energy usage between maintenance intervals. The Burbank facility houses four long aeration basins that were served with two 450 hp blowers and a single 300 hp unit. The blowers are driven by multi-stage motors that were previously operated manually in response to demands for oxygen within the waste flow. The new system incorporates new sensors that monitor oxygen levels in the waste, and can activate the blower motors in proportion to airflow requirements. Demand savings were estimated to be 135 kW, with an accompanying incentive of $54,500.

Key Participants

The City of Burbank used a consultant, Kennedy Jenks from Oregon, to analyze the systems and assess the savings attributable to the conversion to the new membrane diffusers. Once the appropriate diffuser supplier was identified, the City handled the procurement of the components and installation with internal personnel. The project manager, Rodney Anderson, handled the Energy Commission application process.

Technology Overview

Existing ceramic cone aeration diffusers were removed, and a new piping network was installed that enabled the new membrane diffusers to receive pressurized air from the existing blower system. The spacing and density of the diffusers was increased toward the influent side of the basins in order to optimize the oxygen transfer process. Controls were installed that regulate the operation of the blower motors, and can provide air pressure that is directly proportional to the demands for oxygen being monitored in the basins.

Evaluation

Monitoring and Evaluation Procedures

The aeration system was evaluated by performing both pre- and post-installation site inspections to verify both blower capacities and sequences of operation as described in the application. As the blowers are operated on a continuous 24-hour basis, the stated 24-hour per day operational schedule was readily endorsed without need of monitoring. Internal monitoring equipment for the blower motors was cited as the source of demand data during the M&V process and was used to validate the original calculations submitted with the application.

Program Savings

During the course of the post-installation inspection, blower operation was confirmed. Data indicated that the single 300 hp blower was sufficient to serve the entire series of four aeration basins. Previously, one of the 450 hp units was activated during the peak hours of the day (14:00 to 18:00) in addition to one stage of the 300 hp blower motor. Further discussions with plant operations personnel revealed that since the new diffusers were installed, there has not been any need for the 450 hp blowers, and their operations logs reinforced this observation.

Demand savings estimates for the project were submitted at the non-peak level of 135 kW; however, the calculations revealed that peak operations would yield potential demand reductions of 218 kW. Observations of the post-installation operations and the analysis of data from the operable 300 hp blower indicated demand savings of 153 kW for non-peak periods, and 243 kW for peak periods, were more accurate. These demand savings values exceed the submitted calculations by 18 kW for non-peak periods and 25 kW for peak periods. Based on the detailed site inspection and analysis of the revised blower operations, demand savings for the project are verified at 153 kW.

It should be noted that The City of Burbank has contemplated modifications to the treatment standards applied to the wastewater plant. It has been suggested that a more rigorous level of treatment may be demanded of the facility in the future and the escalation of oxygenation levels in the wastewater flow may result in increased blower demands.

Error Analysis

Pursuant to the project's M&V and evaluation efforts, the following sections and accompanying table describe the magnitude and nature of error in the demand savings analysis.

Instrumentation or measurement error: Selected pre- and post-installation demand measurements for the affected blowers were recorded with the use of a Fluke Model 41B true power meter. The manufacturer's specifications identify a potential error of 1 percent for demand measurements within the relevant range.

Modeling error: Calculation methodologies utilized to estimate verified demand savings are assumed to incorporate a modeling error of 15 percent.

Sampling error: All of the affected blowers were reviewed in detail. Subsequently, no sampling error is assigned to the project.

Assumptions of stipulated factors: Nexant assumed a 10 percent error for consistent operating schedules and no use of 450 hp pumps during peak periods.

Table 1: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	1.0
Modeling Error	15.0
Sampling Error	0.0
Assumptions of Stipulated Factors	10.0
Project Total Error	18.1

Program Effectiveness

Verified savings = 153.0 kW
Reported savings = 135.0 kW
Realization Rate = 113.3 percent

Project Number:	**Energy Commission 0161**
Project Name:	**City of Fairfield**

Project Overview

Project Summary

This project included the retrofit of pre-existing T-12 magnetically ballasted fluorescent fixtures with T-8 electronically ballasted fluorescent fixtures. Additionally, incandescent lamps were replaced with compact fluorescent lamps. The project also included installation of occupancy sensors in selected spaces. The lighting retrofit was implemented at multiple city-owned facilities.

Contracted demand savings goal = 120.4 kW

Contracted incentive amount = $38,250

Key Participants

City of Fairfield – Jay Trottier, Assistant to the Public Works Director.

Lighting Technology Services, Inc. served as the lighting contractor, and was responsible for installation of all control system components, lighting fixtures, lamps, ballasts and fixture conversions.

Xenergy is listed in the grant agreement as the project administrator; responsibilities included estimating peak demand savings.

Technology Overview

T-12 magnetically ballasted fluorescent fixtures were replaced with T-8 electronically ballasted fluorescent fixtures. Additionally, occupancy sensors were installed in selected spaces. This retrofit was a citywide effort that reduced lighting energy consumption at a number of city-operated buildings. The retrofit encompassed nearly every lighting fixture in each retrofitted building.

Evaluation

Monitoring and Evaluation Procedures

Baseline lighting equipment was established through pre-installation fixture surveys. Pre-installation inspections served to verify room locations and usage area designations, the number of fixtures included in the retrofit, the number of occurrences of burned-out lamps, and the make and model numbers of existing equipment (including fixtures, lamps and ballasts). For a randomly selected sample of sites, post-installation lighting inspections were performed to verify installation of new equipment. The post-retrofit lighting fixtures were verified during the post-installation inspection, which included an equipment survey of the new equipment identical to that of the pre-installation inspection.

Data loggers were installed to determine operating hours and time-of-use during peak demand periods. Operating hours were assumed to be constant for the pre- and post-retrofit cases. Adjustments were made to reflect non-operating fixtures at all monitored facilities, and to reflect in-session and out-of-session classroom operating hours at school sites. Where applicable, standard wattage lighting tables were used to determine baseline and post-retrofit fixture power demands. Baseline fixture power demands were based on verified equipment from the pre-installation lighting survey; baseline power demands were based on actual equipment and not on any standard performance contracting guidelines for minimum efficiency standards.

Peak demand savings realization rates for the verified lighting fixtures were applied to the participant-supplied inventory of removed and installed equipment.

Program Savings

For the post-installation inspections, Nexant chose to double the sample size while still including the original fixtures sampled in the pre-installation inspections.

Verified savings were determined by first calculating the percent difference between the reported peak power demand reduction and the verified peak power demand reduction in the sample population. The percent difference was then applied to the peak power demand reduction reported for the total population. The difference between baseline and post-installation kW represents peak power demand savings. Peak power demand savings were adjusted by a lighting coincidence factor of 85 percent. Nexant calculated this applied coincidence factor based on monitoring results from Hobo lighting data loggers, based on space types and size. A default adjustment of 10 percent was made to the demand savings figure to account for demand savings resulting from HVAC interactive effects.

Table 1: Time-of-Use Summary

Space Type Code	Percent of Spaces Monitored	Average Peak Period On-Time (from TOU Macro)	Weight
mfg	50%	95%	48%
hall	15%	50%	8%
office	20%	95%	19%
common	10%	80%	8%
restroom	5%	50%	3%
Totals	100%	Weighted Average Coincidence Peak Use Factor	85%

Table 2: City of Fairfield Lighting, Peak Period Demand Savings

Inventory Line Item	Reported Baseline	Verified Baseline	Reported Post	Verified Post
70	122	**103.7**	46	**39.1**
108	144	**122.4**	104	**100.3**
145	288	**489.6**	208	**200.6**
153	804	**683.4**	208	**143.65**
0	216	**183.6**	480	**150.45**
316	1050	**166.6**	280	**178.5**
318	120	**102**	31	**23.8**
320	230	**195.5**	156	**147.9**
478	288	**122.4**	208	**200.6**
485	432	**367.2**	177	**150.45**
497	432	**367.2**	312	**300.9**
528	72	**61.2**	52	**50.15**
538	864	**734.4**	612	**300.9**
590	1728	**979.2**	1224	**752.25**
582	1008	**856.8**	714	**100.3**
623	72	**61.2**	52	**50.15**
712	128	**108.8**	102	**95.2**
791	72	**61.2**	52	**50.15**
Sample Population (Watts)	**8070**	**5766.4**	**5018**	**3035.35**
% diff		*0.7145477*		*0.604892*
Total Population (kW)	**436.4**	**311.8**	**282.4**	**170.8**
Reported savings		***153.9***		
Verified savings		***140.9***		

The peak power demand savings were adjusted based on pre- and post-installation inspections and lighting monitoring results as follows:

Peak power demand savings without 85% coincidence factor adjustment: 165.8 kW.

Peak power demand savings with 85% coincidence factor adjustment: 140.9 kW.

Peak power demand savings with HVAC interactive adjustment: 155.0 kW.

Final Verified Savings (with coincidence factor & interactive effects): = 155.0 kW.

Error Analysis

Nexant applied 5 percent error for use of standard wattage tables. For the calculated lighting coincidence adjustment factor, Nexant assumed an error of 5 percent. Sampling error was calculated at 13.6 percent. A standard error of 10 percent was assumed for the default HVAC interactive factor.

Table 3: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	5.0
Modeling Error	5.0
Sampling Error	13.6
Assumptions of Stipulated Factors	10.0
Project Total Error	18.3

Program Effectiveness

Verified savings	=	155.0 kW
Reported savings	=	95.5 kW
Realization Rate	=	162.3 percent

Project Number:	**Energy Commission 0199**
Project Name:	**City of Fremont**

Project Overview

Project Summary

This project consists of several separate measures designed to reduce peak power demand at two City of Fremont buildings by 124.7 kW. The Energy Commission incentive was for $37,574. The demand reduction measures included the following:

1. Utilization of Direct Digital Controls to control the packaged HVAC units and curtail demand of the units.
2. Replacement of existing packaged HVAC units with more efficient units.
3. A comprehensive lighting retrofit at one of the facilities to replace T-12 magnetically ballasted lamps with T-8 electronically ballasted lamps.

Key Participants

Martha Martinez, Project Manager for the City of Fremont, is the primary contact for this project. She replaced Sheela Dasari as the primary contact. Steve Alexander is the facilities manager who was in charge of implementing the DDC control system for the facility.

Technology Overview

The first measure consisted of curtailing the demand of rooftop HVAC units through the use of direct digital controls (DDC). The DDC system allows for the compressors on the units to be locked-out according to a preset schedule.

The second measure consisted of a simple efficiency retrofit, changing out pre-existing HVAC units with similarly sized, more efficient units. In addition, the new HVAC units use gas heating in place of electric resistance heating.

The third measure consisted of a common efficiency retrofit of T-12 magnetically ballasted lighting fixtures with T-8 electronically ballasted lighting fixtures.

Evaluation

Monitoring and Evaluation Procedures

The M&V plan consisted of performing a pre- and post-installation inspection to verify baseline and installed equipment. Short-term monitoring was performed on a sample of the HVAC units to confirm that the DDC system was operating.

During the pre-installation inspection, Nexant recorded nameplate information on the baseline HVAC units. At the time of the pre-installation inspection, the lighting retrofit had already begun and the entire population of baseline lighting fixtures had been removed from the site.

For the post-installation inspection, Nexant inspected the new HVAC equipment at the Liberty Street building. In addition, the installation of the new T-8 lighting fixtures in the

Capitol Avenue building was verified. At the time of the inspection, loggers were installed on a sample of HVAC units to determine the post-retrofit duty cycles for those HVAC units controlled with the DDC. These data loggers were later removed and analyzed to determine applicable AC unit duty cycles.

Program Savings

The HVAC curtailment savings reported to the CEC were calculated at 41.6 kW. These savings were calculated by dividing the affected HVAC units into four curtailment groups. The four groups were alternately curtailed for 15-minutes each hour. Curtailment consisted of sending a compressor disable signal to each of the appropriate HVAC units. The City of Fremont calculated their demand savings by averaging the total demand of the units in each curtailment group, and multiplying by a stipulated 80 percent duty cycle. This initial analysis did not address how the curtailment affected the overall facility-cooling load, nor did it account for fan power used during periods of curtailment.

After careful analysis, Nexant determined that, as implemented, the DDC system curtailment measure does not consistently reduce peak power demand. Although the curtailment controls limit the operation of the HVAC units to a maximum duty cycle of 75 percent, monitoring data indicated that the average peak period duty cycle of the units does not normally exceed this value. In addition, the DDC system does not control temperature set points (it only performs compressor lockout), and as a result, does not reduce the overall cooling load of the facility. Therefore, the effect of the DDC system controls is to shift the load of the individual HVAC units while not effectively reducing the total cooling load of the facility. After careful analysis, Nexant did not approve any peak demand savings for this measure.

Logging data from nine randomly selected HVAC units was recorded over a period of two weeks. The data showed duty cycles ranging from 2 percent to 61 percent. Nexant calculated the HVAC efficiency improvement peak demand savings by multiplying the full load kW reduction (77.88 kW) by the average package unit duty cycle (35.4 percent), for calculated HVAC savings of 27.6 kW.

Due to the fact that air conditioner unit duty cycles were determined from monitoring in the months of September and October, the average duty cycle for calculating peak demand savings has been normalized to summer months. Nexant calculated the average cooling degree-days for the months of June, July and August; Nexant then calculated the average cooling degree-days for the monitored months of September and October. The ratio of peak period cooling degree-days to monitoring period cooling degree-days was equal to 1.79. The average duty cycle as calculated from monitoring data was adjusted by this factor. The applied AC unit duty cycle is equal to 63.3 percent (adjusted from 35.4 percent). Cooling degree-days were based on bin data from World Climate. Data from San Jose, California, was used because it is the closest climate zone to Fremont, California. After normalizing the AC unit duty cycles, total calculated HVAC savings are equal to 49.3 kW.

Table 1: Fremont HVAC Unit Monitored Duty Cycles

Unit	Tons	Start	End	Duty Cycle
4	5	09/25/02	10/10/02	0.020
6	10	09/25/02	10/10/02	0.370
7	7	09/25/02	10/10/02	0.096
8	7	09/05/02	09/20/02	0.200
9	10	09/25/02	10/10/02	0.400
10	10	09/25/02	10/10/02	0.558
18	3	09/05/02	09/20/02	0.351
19	3	09/05/02	09/20/02	0.580
21	4	09/25/02	10/10/02	0.611
Average Duty Cycle from Monitoring				0.354
Cooling Degree-Days Normalizing Factor				1.790
Normalized Average Duty Cycle from Monitoring				0.633

For the lighting measure, because Nexant could not verify the quantity and type of the pre-installation fixtures, those fixtures were accepted as stated in the application. The 20.8 kW demand savings for the lighting project were determined by calculating the difference in the total demand of the pre- and post-installation lighting fixtures. This methodology assumes that all of the fixtures operate during peak demand periods. Based on Nexant's inspections, it was determined that the fixtures in the council chambers were not operating during peak demand periods. According to the applicant's representative, the council chambers are used primarily in the evening. Nexant estimated the peak demand savings by multiplying the calculated demand savings for the project by a default coincidence factor of 80 percent for standard office space. Nexant calculated direct lighting demand savings of 16.6 kW.

In addition to the direct savings, interactive savings resulting from the reduced cooling load from the lighting reduction were also calculated. Nexant calculated the peak demand savings resulting from interactive cooling effects based on an energy efficiency ratio (EER) of 11 and a corresponding coefficient of performance (COP) of 3.22. The interactive cooling savings were calculated at 5.1 kW. The total demand savings from the lighting measures are 21.7 kW.

Error Analysis

The savings for the lighting and HVAC measures were calculated independently, and therefore have their own respective errors.

For the HVAC measures, three sources of error in the demand savings were identified. While there was measurement error associated with instrumentation, the measured data was used only to determine the state of the unit (i.e. compressor ON/OFF); therefore, no significant error is introduced. Nexant monitoring data showed a large variation in the duty cycles of the HVAC units, resulting in a sampling error of 16.7 percent. Nexant assumed a maximum error of 20 percent in extrapolating the monitored duty cycles to all summer peak demand periods. The Air Conditioning and Refrigeration Institute (ARI) efficiency ratings used in the demand calculations were subject to a 5 percent variation error. The total HVAC error was equal to 26.5 percent.

For the lighting measures, four sources of error were identified. The fixture wattages used in the demand calculation were assumed to have a maximum error of 5 percent. Error for the ARI efficiency ratings used to determine interactive HVAC demand savings was equal to 5 percent. The default lighting coincidence factor was assumed to have a maximum error of 10 percent. Sampling error was assumed at 15 percent. The total lighting error was equal to 19.4 percent.

Table 2: Error Analysis

Source of Uncertainty	Lighting	HVAC
Instrumentation Error	5.0	0.0
Modeling Error	5.0	5.0
Sampling Error	15.0	16.7
Assumptions of Stipulated Factors	10.0	20.0
Total Measure Error	19.4	26.5

Program Effectiveness

Verified savings	=	71.0 kW
Reported savings	=	124.7 kW
Realization Rate	=	56.9 percent

Project Number:	Energy Commission 0299
Project Name:	Ecogate

Project Overview

Project Summary

GL Veneer is a woodworking facility located in Huntington Park. As part of their operations, they require a dust-collecting system to remove the wood dust that is produced throughout the day, as residual dust poses a fire hazard at the facility.

In the base case, two100 hp fan motors ran at full capacity to keep the wood working ducts at a negative pressure in order to prevent wood dust from collecting in the ducts. In the post-installation case, a control system was installed to respond to information from sensors placed at the end of each duct that signaled when a woodworking machine was in use. One of the 100 hp motors was switched out for a new 300 hp motor; both the new 300 hp and pre-existing 100 hp motors were equipped with VFDs. With the control system in place, fan speed ramps up or down depending on the number of wood working machines in use. Demand savings result from the reduction in total required fan motor horsepower. The contracted demand savings goal was 205 kW. The incentive amount totaled $51,250.

Key Participants

Ecogate procured the contract with the Energy Commission and installed the control system at GL Veneer. Jack Sloan was the project contact at Ecogate, and Jeff Levin was the project contact at GL Veneer. Xenergy is listed in the grant agreement as the project administrator; responsibilities included estimating peak demand savings.

Technology Overview

Ecogate does not install or repair ducts. They take existing systems with large dust collectors – designed to run 100 percent on, 100 percent open – and install automated blast gates at each of the duct take-offs. A sensor is placed on each woodworking machine so that only when the machine is on and the cutting heads are working will the control system open the gate to that machine's duct. In this way, a constant negative pressure is maintained. Flash-card technology built into the system takes a snapshot of the facility conditions, including which machines are on and how much power the fan motor is using, at a user-specified interval. At each moment, the control system knows what combination of machines is on and how much airflow is being moved.

The control system can be turned off anytime in order to collect data and to simulate conditions before the equipment was in place. Doing so yielded the baseline energy consumption that was the basis for demand savings calculations.

There are 44 blast gates (22 on each duct system), and each workstation is equipped with a sensor. A central control system (the greenBOX MASTER) synthesizes all the information from all of the duct takeoffs. The greenBOX MASTER regulates the speed (power) of the dust collector fan via a PowerMASTER unit.

Evaluation

Monitoring and Evaluation Procedures

The installed system at the GL Veneer facility is an industrial system by EcoGate, which includes fan motor VSDs and controls, in addition to sensors and controls on all of the dust-producing machines in the factory. The VSD and machine-controls are coordinated by a computer that calculates the necessary pressures and CFM in the system based on the machines that are on at the time, and then controls the blast gates and VSD to meet exactly those needs, thereby reducing the overall demand and energy use of the dust-collecting system. The accompanying EcoGate monitoring system allows the user to disable the controls and take data on the system as it was before the installation of EcoGate technology for comparison to post-installation conditions.

Nexant's M&V activities included a pre-installation inspection of the GL Veneer facility on February 12, 2002. During this inspection, it was noted that two 100 hp motors were running at full load, new main ductwork was being installed, the greenBOX MASTER and PowerMASTER control systems were both mounted but not yet connected, and the re-manufactured 300 hp motor which was installed as part of the new system had the following nameplate data: IM TEFC 3-phase motor, serial #100041A, 300 hp, 1787 RPM, 460V, 328 Amp, PF=0.89, 80 F temperature rise, 94.5 percent efficiency at ¾ L/C, and 94.1 percent guaranteed efficiency.

Nexant performed a post-installation inspection on December 19, 2002 in order to verify that the proposed equipment was in place and operational, which it was. Fan energy usage data was downloaded from the greenBOX MASTER and PowerMASTER control boxes and a real power spot measurement was performed on the 300 hp motor. Data from that spot measurement is presented in Table 1 below. Nexant's post-installation inspection served two purposes: to verify that the equipment was installed and to verify the accuracy and validity of the EcoGate power savings as calculated by Xenergy.

Table 1: Post-Installation Real Power Spot Measurements and Calculations

Measured Data		Real Power Calculations		Nameplate/Given Data	
Vab	335.8	I-avg=	126.4	Sqrt 3=	1.732
Vbc	344.3	V-avg=	343.2	PF=	0.89
Vca	349.4	PF=	0.89	Efficiency=	0.94
Ia	128.3	Real kW=	66.8	kW/HP=	0.746
Ib	120.0	Rated kW=	238.0	Motor HP=	300
Ic	130.8	% Load=	28%		

Program Savings

The grant agreement project administrator, Xenergy, Inc., submitted to Nexant a summary of demand savings resulting from the EcoGate project. The data submitted was measured kW following installation. The data showed that greenBOX MASTER and PowerMASTER systems were operational by September 30, 2002. However, demand savings were calculated based on monitoring data from five weekdays during the period of October 16 to October 22, 2002. Due to start up problems, monitoring data previous to

October 16, 2002 was not useful. While this data was not collected during summer months, it was assumed that typical facility operations do not demonstrate any significant seasonal variation. EcoGate's post-installation monitoring results, as submitted by Xenergy are presented below in Table 2.

Table 2: EcoGate Post-Installation Monitoring Data

Date	Hour	300 hp Avg. kW	100 hp Avg. kW	300 hp Savings (kW)	100 hp Savings (kW)
10/16/02	14	95.9	53.7	112.2	36.3
	15	91.9	49.2	98.8	40.8
	16	0.0	0.0	0.0	0.0
	17	0.0	0.0	0.0	0.0
10/17/02	14	103.5	50.2	104.5	32.3
	15	105.5	55.1	102.5	34.9
	16	0.0	0.0	0.0	0.0
	17	0.0	0.0	0.0	0.0
10/18/02	14	8.7	4.9	8.7	10.1
	15	0.0	0.0	0.0	0.0
	16	0.0	0.0	0.0	0.0
	17	0.0	0.0	0.0	0.0
10/21/02	14	106.3	54.9	101.7	35.1
	15	2.3	4.5	15.0	3.1
	16	0.0	0.0	0.0	0.0
	17	0.0	0.0	0.0	0.0
10/22/02	14	104.0	57.7	104.0	32.3
	15	99.2	52.8	108.8	29.7
	16	20.7	14.3	31.3	8.2
	17	0.0	0.0	0.0	0.0
Average		36.9	19.9	39.4	13.1

The savings calculations presented in Table 2 were calculated by EcoGate and Xenergy as the difference between monitored post-installation kW consumption (from the greenBOX MASTER and PowerMASTER systems) and baseline peak power demand as determined by spot measurements. The baseline kW for the 100 hp motor was 90 kW due to low motor efficiency. The baseline kW for the 300 hp motor was 208 kW due to its being re-manufactured. Savings were calculated for the two duct systems separately.

Total peak demand savings for the 300 hp duct and the 100 hp duct totaled 52.5 kW. However, as the project involved an overall increase in duct horsepower from 200 hp to 400 hp, Nexant determined that the submitted peak power demand savings for the 300 hp motor overestimate actual reduction to peak power demand. Therefore, Nexant approves all the reported savings for the 100 hp motor and 1/3 of the reported savings for the 300 hp motor. This adjustment assigns peak power demand savings based on actual, not theoretical, baseline capacity. Total peak power demand savings are approved at 26.2 kW.

Error Analysis

Per Ales Litomisky at Ecogate, instrumentation error in the greenBOX MASTER system is on the order of 3 percent. A modeling error of 20 percent is also assigned, as the peak demand savings were based on only five consecutive weekdays of power monitoring.

Table 3: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	3.0
Modeling Error	20.0
Sampling Error	0.0
Assumptions of Stipulated Factors	0.0
Project Total Error	20.2

Program Effectiveness

Verified savings = 26.2 kW
Reported savings = 52.5 kW
Realization Rate = 49.9 percent

Project Number:	**Energy Commission 0301**
Project Name:	**Fresno Chamber of Commerce**

Project Overview

Project Summary

The Fresno Area Chamber of Commerce used small grant monies to run a "mini" third-party-administered program. The Chamber recruited small area businesses to participate in a lighting efficiency retrofit program, whereby the Chamber negotiated bulk rates on lighting equipment and installation for a group of small businesses. The Chamber used grant money to pay for all but a fraction of the retrofit cost. This program was unique in that it aimed to enlist a large number of historically hard-to-reach small business customers who previously did not have the capital or access to the information necessary to implement such a retrofit in their facility.

The City of Fresno originally had two applications with the Energy Commission (301 and 302). The total contracted demand savings goal for both of these applications was 243.3 kW at the Grant Agreement stage. This figure took into account not only lighting savings, but also associated savings in facility cooling loads. The incentive amount totaled $60,825.

Between the execution of the Grant Agreement and completion of the lighting retrofit, a number of project changes occurred. Some of the original program participants dropped out and were substituted with others (at the approval of Wesley Sullens of Xenergy). Also, the Fresno Chamber of Commerce ran out of time to implement both the applications it had with the Energy Commission, and so combined them into one (301). This is one reason why the final kW savings are different from the original estimates. Additionally, Fresno was penalized for completing the project late. The final kW savings figures and incentive approved by Xenergy were 243.3 kW and $68,601, respectively.

Key Participants

Fresno Chamber of Commerce contracted with Xenergy to aggregate a number of small businesses to participate in the Rapid Response program.

Technology Overview

T-12 magnetically ballasted fluorescent lamps were retrofitted with T-8 electronically ballasted fluorescent lamps. In addition to savings associated with the T-12 to T-8 lamp change out, fixtures were also delamped from 4 to 2 lamps, 3 to 2 lamps, and 2 to 1 lamp. No lighting controls were installed under this program.

Evaluation

Monitoring and Evaluation Procedures

As part of Nexant's M&V activities, pre- and post-installation site inspections were performed at a sample of retrofit sites. On February 21, 2002, Nexant staff met with Kevin Fantz, the Chamber's program administrator, and performed inspections at three project sites. On April 10, 2002, Nexant staff met with Kevin Fantz and performed site inspections at six additional sites.

Lighting inspections were performed to verify installation of new equipment. Baseline equipment performance was established through pre-installation equipment and fixture surveys. During inspections, the following were noted: room location and usage area designation, the number of fixtures that were retrofitted, the number of occurrences of burned-out lamps, and the make and model numbers of existing equipment (including fixtures, lamps and ballasts).

The post-retrofit performance was established through the post-installation fixture surveys, which included an equipment survey of the new equipment identical to that of the pre-installation surveys. Data loggers were installed to determine operating hours during peak demand periods. Operating hours were assumed to be constant for the pre- and post-retrofit cases. Adjustments were made to reflect non-operating fixtures at all monitored facilities, and to reflect in-session and out-of-session classroom operating hours at schools sites. The applied lighting coincidence factors were determined from Nexant's data logger analysis.

Xenergy submitted baseline and post-installation lighting fixture wattages to Nexant. Nexant subsequently performed its own due diligence review for all applied fixture wattages based on Nexant's inspection findings. Nexant found that Xenergy's lighting fixture wattages were accurate. Fixture wattages were based on actual equipment, and were not based on any minimum efficiency codes or standards. Based on information submitted by Xenergy, and inspection findings at sampled sites, including calculated coincidence factors and calculated interactive HVAC demand savings, results were extrapolated to the balance of the sites based on participant-supplied inventories of removed and installed equipment.

Program Savings

Nexant calculated total savings to be 217.7 kW. See Table 1 below.

Table 1: Nexant Verified Savings

Fresno Chamber of Commerce	Pre June 1, 2002	Post June 1, 2002	Total
Lighting kW saved	***129.9***	***25.8***	***155.7***
Hourly Btu's saved	443,091	88,033	531,124
AC tons saved	36.9	7.3	44.3
Cooling savings @ 1.4 kW/ton	***51.7***	***10.3***	***62.0***
Total	***181.6***	***36.1***	***217.7***

Error Analysis

Total project error is calculated below. Standard fixture wattage tables have a stipulated maximum error of 5 percent. Error from the calculated coincidence factors was assumed to be 5 percent. A 10 percent sampling error was assumed. A 5 percent error was assumed for the efficiency ratings used to determine interactive HVAC demand savings. Total lighting error is equal to 13.2 percent.

Table 2: Error Analysis

Source of Uncertainty	Percent Error
Instrumentation Error	5.0
Modeling Error	5.0
Sampling Error	10.0
Assumptions of Stipulated Factors	5.0
Project Total Error	13.2

Program Effectiveness

Verified savings = 217.7 kW
Reported savings = 249.3 kW
Realization Rate = 87.3 percent

Lighting Efficiency Retrofit and HVAC Interactive Savings

Lighting efficiency retrofits result in a reduction to building cooling load during summer peak period hours, and therefore a reduction to chiller compressor kW power demand. Such measures also result in an increased heating load during winter months. However, as the focus of SB5X was demand reduction during summer peak demand periods, Nexant has defined HVAC interactive savings effects as marginal reductions to total cooling load resulting from lighting efficiency retrofits.

There are three main M&V options for capturing the HVAC interactive savings. These options are explained below[1]:

> Option A – Stipulating the interactive savings. Calculation can be performed based on standard values of interactive savings for the climate and HVAC equipment type. An ASHRAE Journal article by Rundquist et al. presents an approach for calculating interactive savings. Again, as with all Option A approaches, the results may not be very accurate for the particular facility, and it may be a problem for the facility owner in a shared savings arrangement.
>
> Option B – Meter the HVAC units before and after retrofit and calculate the savings based on the load. While capable of producing very accurate results of the interactive savings, the expense and expertise needed to perform this type of monitoring can get expensive. Monitoring equipment will need to capture a full range of outside air temperature and interior loads to extrapolate the energy use patterns throughout the year, which will require the monitoring equipment to be installed for a significant period of time on each HVAC unit. Determining building load is not a simple task, with tricky airflow measurements needed. The relative expense of this option virtually rules it out.
>
> Option D – Construct a calibrated simulation of the facility to predict the interactive savings. Some expertise in building modeling will be required to produce a calibrated model of the facility. Additionally, lighting loads will have to be converted to watts per square foot, for each zone of the building served by a HVAC unit. This method can get expensive, but given an experienced modeler and calibrating the model to the facility's utility bills, it should produce accurate results.

For all projects, Option D proved to be financially infeasible. Whenever possible, Nexant employed Option B; meaning that metered or nameplate data from HVAC units was used to calculate interactive HVAC savings for summer peak demand periods.

If Option B was not possible, Nexant employed Option A, using a stipulated AC interactive savings default factor of 10 percent. Option A was employed when lighting retrofits involved numerous buildings and numerous HVAC systems. In these cases, Nexant was not able to accurately calculate interactive savings resulting from lighting retrofits. These projects also involved discrepancies between the areas where HVAC systems operated and the areas where retrofitted lighting systems operated. For all of the aforementioned reasons, Nexant chose to stipulate AC interactive effects for lighting efficiency retrofits where Option B was not possible.

To stipulate a parameter is to hold its value constant regardless of what the actual value is during the contract term or the life of the measure. Stipulated values must be based on reliable, traceable, and documented sources of information. Stipulating parameters that represent a small degree of uncertainty and a small part of overall savings will not increase uncertainty significantly.

[1] DETAILED GUIDELINES FOR FEMP M&V OPTION A, May 29, 2002, U.S. Department of Energy, Federal Energy Management Program. Developed for the U.S. DOE Federal Energy Management Program by Nexant and Lawrence Berkeley National Laboratory.

For all projects in which Option A was employed, Nexant applied a 10 percent default interactive HVAC savings factor. In California, typical buildings have interactive factors between 3% and 15%, depending on system type and efficiency. The primary drivers of interactive factor are chiller efficiency, HVAC system type, building size and climate zone.[1] Building cooling loads are typically highest during summer peak demand periods, meaning that associated interactive savings resulting from reduced lighting loads are most important during these peak periods. As interactive cooling factors increase with increasing ambient temperatures, interactive savings are highest during summer peak demand periods. For summer peak demand periods, Nexant concluded that 10 percent was an appropriate, and relatively conservative, default factor.

Default Lighting Coincidence Factors

The amount of demand reduction achieved by a lighting project will depend on how many of the lights are operating when the building peak demand occurs. It is unlikely that all lighting fixtures will be operating when the peak demand is set, so summing the demand reduction from all affected fixtures will overstate the demand reduction seen in the utility bill. The fraction of lights operating when the peak demand is set is known as the *coincidence facto*r, which can range from 0 percent (outside lights that operate only at night) to 100 percent (continuously operating lights). It is difficult to accurately determine coincidence factors without taking time-of-use measurements.[2]

For those lighting retrofits included in the Innovative Program where time-of-use measurements were not possible due to constraints of time, budget, building size, building space, and total number of buildings retrofitted, Nexant applied a stipulated coincidence factor of 80 percent. The stipulated 80 percent coincidence factor is an industry standard default for standard office space. For those lighting retrofits with sufficient time-of-use monitoring data, the applied coincidence factors were calculated using monitored data and Nexant's in-house Time-of-Use MACRO program.

[1] SCE DSM Bidding Program: Program Guidelines and Recommended Procedure, Version 4.1, Appendices Section D, Chapter 18, Default Interactive Factors, 1995.

[2] DETAILED GUIDELINES FOR FEMP M&V OPTION A, May 29, 2002 U.S. Department of Energy, Federal Energy Management Program, Developed for the U.S. DOE Federal Energy Management Program by Nexant and, Lawrence Berkeley National Laboratory.